

SEA-STARS OF NORTH CAROLINA

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ABSTRACT

Descriptions, keys to identification, and photographs are given for the 22 genera and 33 species of North Carolina asteroids. The starfish fauna is predominantly "southern." Eighteen species are distributed from North Carolina southward, nine range from North Carolina northward, and six occur both north and south of North Carolina. The affinities of the various

species to the principal marine biotic provinces are discussed. Thirteen tropical and subtropical species occur only in an extension of the Caribbean Province along the outer shelf. Only four of the 33 species on the Continental Shelf can be considered abundant: *Astropecten articulatus*, *Luidia clathrata*, *Astropecten americanus*, and *Asterias forbesii*.

Although isolated records exist, no previous attempt appears to have been made to bring together a list, with workable keys for their identification, of the asteroids that occur in North Carolina waters. Only the inshore, shallow-water species are well known. Pearse and Williams (1951) in their study of reefs off New River Inlet added two species new to North Carolina records and Cerame-Vivas and Gray (1966) listed six others. Sampling has been extensive in recent years; at least 33 asteroids are now known from the North Carolina Continental Shelf, and probably many additional species occur in deeper waters off the shelf. The need for identification sources for starfishes in this area has become acute because of the marked increase of interest in marine biology, the expansion of opportunity for oceanographic training, and the greater frequency of research cruises and offshore collecting by university classes in marine ecology and invertebrate zoology.

The present discussion is limited to the Asteroidea of the Continental Shelf; deep-sea species, even though in the latitude of North Carolina, are not included. The 200-m. contour, near the edge of the shelf, makes a convenient seaward boundary

of the area under consideration. Depth increases rapidly on the slope, and species of the continuously cold waters of the slope and beyond live in a different environment and more properly belong to the deep-sea benthos.

METHODS

SAMPLING PROCEDURES

Other than the fact that all starfishes are marine no single environmental condition is common to all species. Asteroids differ in habits, habitats, depths of water at which they occur, and in tolerance to adverse conditions. Consequently, no one sampling technique is adequate for all species. Hand-picking from jetties and the use of light dredges operated from small craft are satisfactory for collecting some species. Heavy gear is essential for dredging in deeper waters and on rocky ledges.

Especially useful to us, because they cut into the substrate, were the heavy Cerame-Vivas rock dredge (locally known as the C-V dredge) and the Cape Town dredge (also known as the Day dredge, because it was introduced by John Day of the University of Cape Town). The frame of the C-V dredge (Cerame-Vivas and Gray, 1966) was fashioned from scrap metal and, with lead shoes added, weighed over 200 kg. The leading edge consisted of a bulldozer blade estimated to cut into a substrate of hard-packed sand a minimum of 12

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cm. The mouth opening was slightly over 1 m. in width. This rugged dredge was used on rocky ledges as well as on level bottoms. Use of the smaller, lighter, and less rugged Cape Town dredge was limited mainly to level bottoms. Chartered shrimp trawlers and Duke Marine Laboratory's RV *Eastward* were used in the dredging.

For such forms as *Astropecten* and *Luidia* that glide over the sandy substrate and feed by ingestion of numerous small surface organisms, commercial trawls proved very satisfactory. Diving on reefs in relatively shallow water and using SCUBA (Self Contained Underwater Breathing Apparatus) produced some species not taken by other means, but this excellent collecting method was not used beyond a depth of 30 m.

Bottom photographs have sometimes helped demonstrate relative abundance, but only rarely can these be used alone for positive identification of species. Also, many sea-stars cannot be satisfactorily photographed because they bury themselves beneath the substrate and leave only an imprint to indicate their presence.

Probably some species which appear to be scarce would prove to be more abundant if more suitable methods for their collection were used, especially on reefs, ledges, and rock outcroppings too deep for normal SCUBA diving.

Not all parts of the shelf have been sampled with equal intensity, and our list of asteroids is probably incomplete. The most frequent collections have been made between the latitude of Oregon Inlet, well north of Cape Hatteras, and New River Inlet, well south of Cape Lookout. Material is more scanty from the area off Cape Fear and Fry-ing Pan Shoals. Nevertheless, we believe that the data presented justify the assumption that most of the species to be found in North Carolina are included, since the areas that have been extensively sampled cover the principal marine biotic provinces. The most serious potential source of error lies not in the range of latitude sampled but in the lack of adequate collections from reefs and hard bottoms.

PRESERVATION TECHNIQUES

Starfishes should preferably be relaxed before preservation, but this is not always possible on shipboard. Some species normally remain flat, but in others the arms tend to curl. They can be relaxed and preserved in sea water in a flat enamel pan

large enough for the specimens to spread out without touching one another. The sea-stars flatten if magnesium sulphate (Epsom salt) is sprinkled on the water or if fresh water is added, a little at a time, until the sea water is replaced. Regardless of method, after relaxation is completed the water should be replaced by 70 percent alcohol or by 6 percent neutralized Formalin.⁴ Echinoderms should never be kept permanently in Formalin, however, as it destroys their calcite plates. Unfortunately, and perhaps unavoidably, alcohol removes much of the color. Usually it is more satisfactory to dry specimens after they have been preserved; this solves many storage problems. If later there is need to examine soft parts (e.g., to determine whether or not the podia have suckers), the whole specimen, or better still, a single arm can be soaked for a few hours in ordinary detergent. To examine underlying plates or other hard parts, soft tissue can be removed by dipping the appropriate part of the animal in household bleach. Bleach must be used carefully; excessive amounts can easily remove all connective tissue holding the plates together. The action of bleach can be quickly ended by rinsing the specimen in running water. It is best to treat only one arm of a specimen, as it may be desirable later to check certain anatomical features of the soft tissues.

To examine pedicellariae, one or two can be removed under magnification with fine forceps and placed on a glass slide with a drop of dilute bleach. Bleach will not always be necessary, as the valves of the pedicellariae are sometimes clearly visible without further treatment.

BIOGEOGRAPHICAL AREAS

Analysis of the distribution of any major group of benthic species on any segment of the North Atlantic Continental Shelf holds more than local interest. This is especially true of the North Carolina section of the shelf, which in any discussion of north-south distribution of species occupies a position of marked biogeographic importance. Located about midway on the U.S. Atlantic coast between temperate New England and subtropical Florida, the North Carolina shelf has several marine climates and associated temperature barriers within relatively few kilometers. Several capes,

⁴Trade names referred to in this publication do not imply endorsement of commercial products.

especially Cape Hatteras, project onto the shelf and divert water masses. The southwesterly flowing Virginian Coastal Current brings cool water from Cape Cod to Cape Hatteras before it is shunted seaward, and the warm Florida Current flows northeasterly and overlaps the outer edge of the shelf to a point well north of Cape Hatteras. The Carolinian Coastal Current, varying greatly in intensity depending on wind regimes, flows southwesterly from Cape Hatteras. The width of the shelf varies from less than 32 km. off Cape Hatteras to more than 80 km. across Onslow Bay. As shown by Cerame-Vivas and Gray (1966), boreal animals from the north and subtropical species from the south are both able to maintain themselves in North Carolina waters. This does not imply that the Continental Shelf of North Carolina is necessarily a transition zone between northern and southern species, but rather that species with different geographic affinities may occur in ecologically different areas in North Carolina waters, even at the same latitude.

Three marine biotic areas (fig. 1) have been recognized on the North Carolina Continental Shelf (Cerame-Vivas and Gray, 1966):

- A. The Virginian Province is a cold-water, wedge-shaped area that has its apex at Cape Hatteras and widens to the width of the shelf near the latitude of Oregon Inlet. This region is heavily influenced by the Virginian Coastal Current.
- B. The Carolinian Province extends southward from Cape Hatteras and occupies the inner two-thirds to three-fourths of the shelf. In addition to its own fauna, this area receives contributions from the Virginian Province in winter and from the Caribbean Province in summer.
- C. An extension of the Caribbean Province forms the outboundaries of both the Carolinian and Virginian Provinces and constitutes the outer shelf under the Florida Current. Northward it extends to the point where the Florida Current leaves the shelf. Because of the meanderings of the Florida Current over the edge of the shelf under different wind regimes (Bumpus, 1955; Bumpus and Pierce, 1955; Gray and Cerame-Vivas, 1963), neither the northern nor western limits of the Caribbean Province can be precisely defined.

The boundary between Virginian and Caribbean Provinces forms a much more formidable barrier to distribution than the barrier between Carolinian and Caribbean Provinces, which in summer is rather diffuse. The "Hatteras Barrier" between the Virginian and Carolinian Provinces is frequently broken in winter when persistent northeast winds (the prevailing winter winds) push Virginian coastal waters past Cape Hatteras and Diamond Shoals into Raleigh Bay and beyond (Bumpus and Pierce, 1955; Wells and Gray, 1960; Gray and Cerame-Vivas, 1963), creating favorable conditions for "northern" species to live in the Carolinian Province temporarily.

ABUNDANCE AND DISTRIBUTION

Although level bottoms of sand and mud predominate on the North Carolina shelf, scattered here and there are hard substrates: reefs of Trent Marl covered with calcareous tubes of mollusks, coquina formations, encrusted *Lithothamnion* algae, patches of coral, shelly areas, and wrecks that support a varied and abundant biota. The submerged reefs are well known to fishermen but, unfortunately, have been little studied by biologists. Pearse and Williams (1951) pioneered in describing the biota of the reefs off New River Inlet. More recently Menzies, Pilkey, Blackwelder, Dexter, Huling, and McCloskey (1966) made a comprehensive study of a *Lithothamnion* reef near the edge of the shelf off Onslow Bay. The fauna listed was predominantly tropical and subtropical. Pearse and Williams reported four sea-stars on their inshore reefs; Menzies et al. (1966) identified but one asteroid from their offshore reef. Granite substrates are limited to the inshore, shallow-water man-made jetties. Not all sea-stars require a hard substrate, but some that do (*Echinaster spinulosus* and *Thyraster serpentarius*, for example) are not abundant elsewhere. Grass beds (principally eelgrass *Zostera* and widgeon grass *Ruppia*), limited to soft bottoms of the estuaries, may be ignored as habitats for starfishes, although occasionally the very young of *Asterias forbesii* are found here.

The 33 species of sea-stars definitely known to occur on the North Carolina Continental Shelf fall into 22 genera. Of the four genera that have

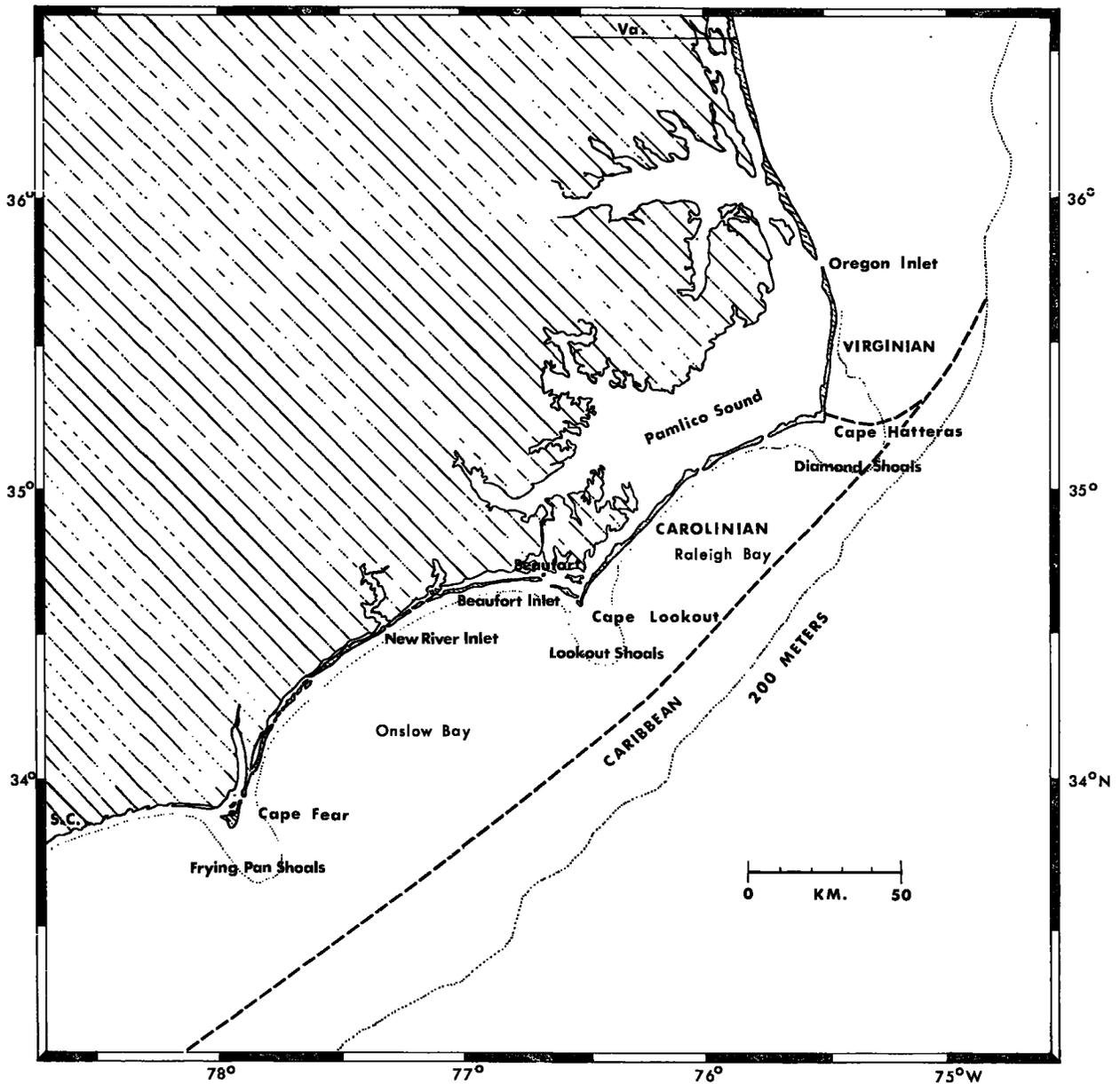


FIGURE 1.—Map of the North Carolina coast showing relation of the three major biotic provinces (Virginian, Carolinian, and Caribbean) to Cape Hatteras and the Continental Shelf. The heavy broken lines indicate the approximate boundaries between the provinces.

more than one species, three contain the four most common species. These are, in order of abundance: *Astropecten articulatus*, *Luidia clathrata*, *Astropecten americanus*, and *Asterias forbesii*. The first two occur in large numbers on level bottoms in 10 to 100 m. in Raleigh Bay and Onslow Bay, and commonly appear together in trawls of shrimp and scallop fishermen. Their numbers diminish north of Cape Hatteras and nearer the edge of the shelf.

Astropecten americanus, on the other hand, is abundant north of Cape Hatteras but is rare south of the cape. *Asterias forbesii*, a shallow-water species, is the only sea-star that lives permanently within the estuaries. At times it is very abundant on the jetties. *Astropecten articulatus* and *L. clathrata* are sometimes discarded in the estuaries by shrimp fishermen when they clean their nets and boats, but these species seem to be unable to survive

here throughout the year—perhaps from lack of suitable substrate on which to feed, or because of their inability to withstand winter cold or occasional lowered salinity in the shallow estuaries.

The starfishes of North Carolina predominantly have a southern affinity. Eighteen species range from North Carolina southward and nine from North Carolina northward. Only six are found

both north and south of North Carolina, and four of these are more southern than northern. One (*Coscinasterias*) extends only as far north as Virginia, and three as far as New Jersey. Comparison of figures 2 and 3 shows that strictly “northern” species—those that range northward from North Carolina—are rare south of Cape Hatteras. They appear in the cool south-flowing Virginian Coastal

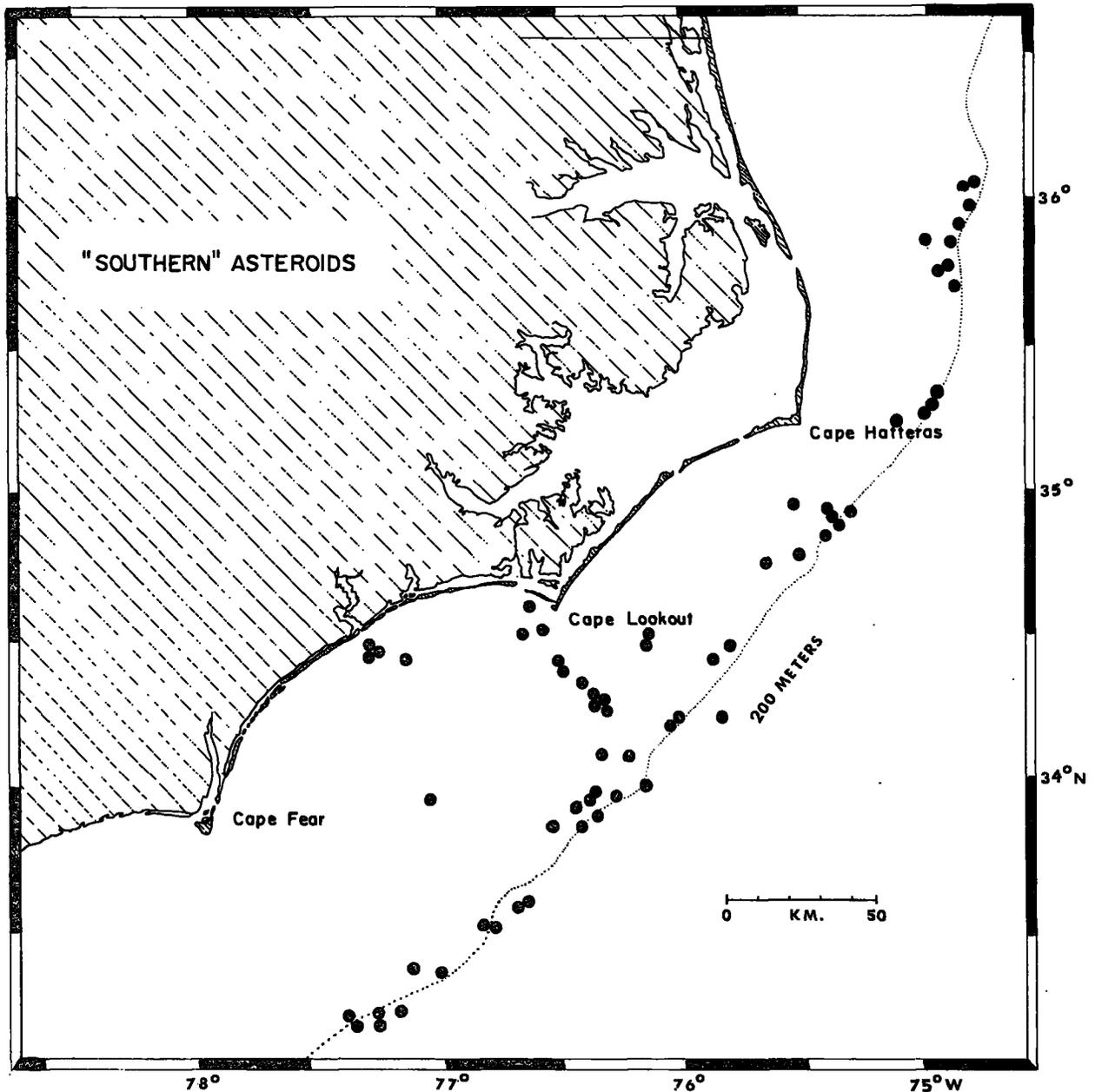


FIGURE 2.—Stations in North Carolina at which 16 of the 18 “southern” asteroids have been taken.

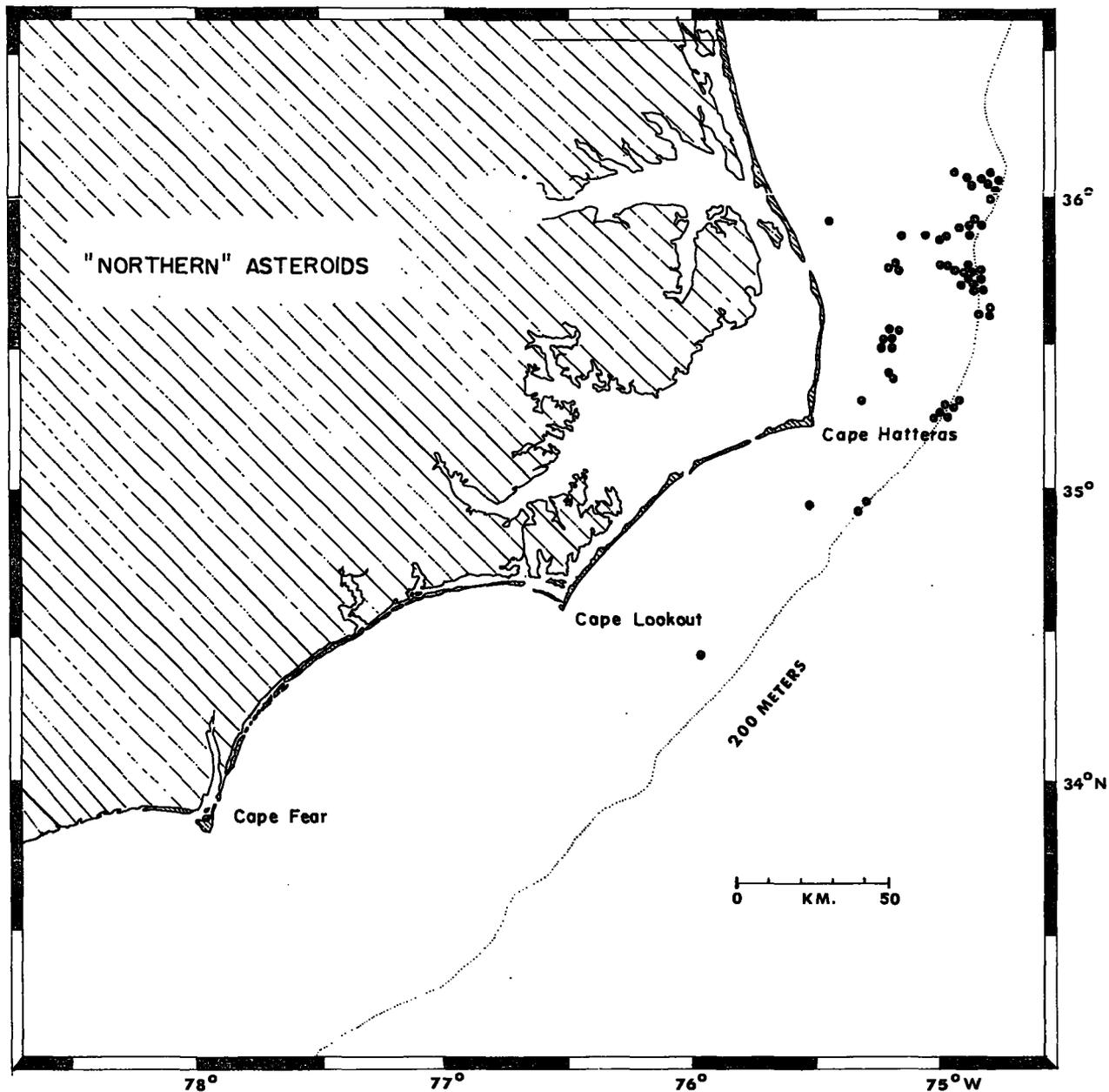


FIGURE 3.—Stations in North Carolina at which seven of the nine "northern" asteroids have been taken.

Current or in deeper waters near and off the edge of the shelf. On the other hand, "southern" species—those that are distributed from North Carolina southward—rarely are taken in stations north of Cape Hatteras except near the edge of the shelf under the Florida Current.

A greater number of species, but smaller populations, occur along the outer shelf (110-200 m.),

whether in the Caribbean Province or north of it, than in either the Virginian or Carolinian Province. Either or both of two factors not easily separated may account for this distribution: depth and more uniform temperature. The range of bottom temperatures of the outer shelf is far less than that of either the middle or inner shelf. North of lat. 35°30' N., northern and southern species ap-

pear to overlap somewhat. The few stations from which tropical species have been taken in this region may be under the Florida Current at some times but not at others, owing to the meanderings of the current. Also, the average bottom temperature is higher than it is nearer shore or in the deeper water of the slope.

Table 1 indicates the affinities of the various species in relation to their geographic ranges and to the biotic provinces of the shelf. The distribution of North Carolina asteroids largely follows the distribution pattern shown by Cerame-Vivas and Gray (1966) for other benthic species of the area.

TABLE 1.—*Asteroidea known to occur in North Carolina waters, their geographic affinities, and areas of distribution on the Continental Shelf*

Geographic affinity and species	Biotic Provinces		
	Virginian	Carolinian	Caribbean
Northern and Southern:			
<i>Coronaster briareus</i>	X	-----	-----
<i>Odontaster hispidus</i>	XX	X	-----
<i>Asterias forbesii</i>	XX	XX	-----
<i>Astropecten articulatus</i>	XX	XX	X
<i>Luidia clathrata</i>	X	X	XX
<i>Tethyaster vestitus</i>	-----	-----	X
Northern:			
<i>Asterias vulgaris</i>	X	-----	-----
<i>Ctenodiscus crispatus</i>	XX	-----	-----
<i>Henricia sanguinolenta</i>	XX	-----	-----
<i>Leptasterias tenera</i>	XX	-----	-----
<i>Pellaster planus</i>	XX	-----	-----
<i>Porania insignis</i>	XX	-----	-----
<i>Astropecten americanus</i>	XX	X	X
<i>Asterias tanneri</i>	X	-----	XX
<i>Mediaster bairdii</i>	-----	-----	X
Southern:			
<i>Echinaster sentus</i>	-----	X	-----
<i>Echinaster spinulosus</i>	-----	XX	-----
<i>Thyraaster serpentarius</i>	-----	XX	-----
<i>Astropecten duplicatus</i>	-----	XX	X
<i>Coscinasterias tenuispina</i>	-----	XX	XX
<i>Luidia alternata</i>	-----	X	XX
<i>Astropecten nitidus</i>	-----	-----	XX
<i>Astropecten nuttingi</i>	-----	-----	XX
<i>Echinaster brasiliensis</i>	-----	-----	XX
<i>Goniaster americanus</i>	-----	-----	XX
<i>Linckia bouvieri</i>	-----	-----	XX
<i>Luidia bernasconiatae</i>	-----	-----	XX
<i>Luidia elegans</i>	-----	-----	XX
<i>Narcissia trigonaria</i>	-----	-----	XX
<i>Oreaster reticulatus</i>	-----	-----	XX
<i>Plinthaster dentatus</i>	-----	-----	XX
<i>Solaster caribbaeus</i>	-----	-----	XX
<i>Stephanasterias gracilis</i>	-----	-----	X

The entire benthic fauna is largely "southern," that is, more species range southward from North Carolina than range northward. Fourteen of the 33 asteroids, all tropical or subtropical, occur only in the Caribbean Province. No strictly tropical species gets into the Virginian Province. On the other hand, some of the northern species do find their way into the Carolinian Province and sometimes into the Caribbean Province, especially at its northern end. Only three starfishes were found in

all three biotic areas—but not in equal abundance in all of them. For example, *Luidia clathrata* and *Astropecten articulatus* are much more abundant in the Carolinian Province than in either the Virginian or Caribbean Province. The only "northern" species not collected in the Virginian Province is *Mediaster bairdii*. Thus far this species has been collected only from the edge of the shelf off Cape Lookout. Similarly, *Tethyaster*, a species that ranges both north and south of North Carolina, has been taken only in the Caribbean Province.

IDENTIFICATION OF SPECIES

Although the following keys cover the sea-stars now known to occur on the North Carolina shelf, it would not be surprising if additional species, especially Caribbean species, were collected from time to time. Technical terms are defined in the glossary and illustrated in figure 4. Additional details of morphology may be obtained from Hyman's (1955) volume on the Echinodermata, from which much of the terminology used here has been taken.

GLOSSARY

- Abactinal*: Upper or aboral surface opposite mouth and ambulacral grooves.
- Aboral*: See abactinal.
- Actinal*: Oral or lower surface on which mouth and ambulacral grooves are situated.
- Adambulacrum*: Ossicle in series bordering ambulacral groove adjacent to ambulacral ossicles.
- Alveolar pedicellaria*: Pedicellaria with two valves which are partly sunken into a depression on a plate.
- Ambulacrum*: Groove on the actinal surface of the arm, from mouth to arm tip, containing the tube feet. Also, a plate of the double series flooring the ambulacral groove.
- Ampulla*: Rounded (single) or bilobed (double) sac above each tube foot.
- Bivalved pedicellaria*: Pedicellaria having two valves.
- Capitate*: Enlarged at tip.
- Carina*: Distinct median row of plates on aboral surface of arm.
- Clavate*: Club-shaped.

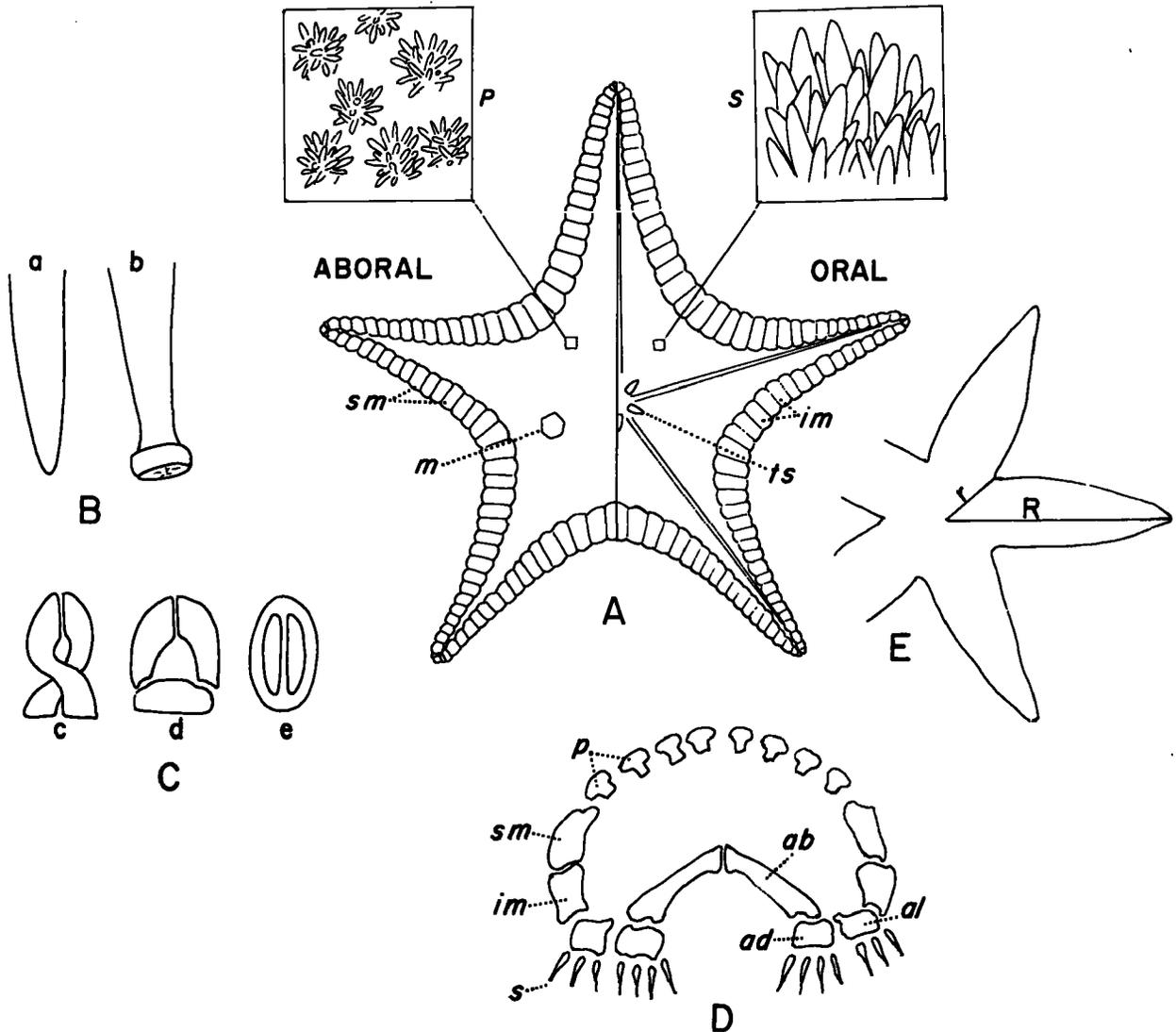


FIGURE 4.—Some morphological characteristics used in identification of asteroids (somewhat schematic). A. Aboral and oral sides of a starfish (*Odontaster hispidus*). B. Podia, without (a) and with (b) sucker. C. Pedicellaria, crossed (c); straight (d); and bivalve (e). D. Arm in cross section, showing ossicles. E. Radii. ab, ad, al—ambulacral, adambulacral, and actinolateral ossicles; im, inferomarginal plates; m, madreporite; p, paxillae; R, long radius; r, short radius; s, spines; sm, superomarginal plates; ts, tooth spine.

Cribriform organ: Vertical depression between adjacent marginals, lined with a series of thin vertical plates (lamellae).

Disc: Body of starfish, exclusive of arms.

Epiproctal cone: A sharp dermal elevation in the center of the aboral surface of certain starfish.

Fasciolated: Banded with small spinules, or ciliated.

Feliped pedicellaria: Straight pedicellaria with overlapping claws resembling a cat's forepaws when faced together.

Furrow: Groove running between adjacent series of plates.

Granule: Small grain.

Hyaline: Clear, glassy.

Imbricate: Overlapping.

Inferomarginal: Plate in lower marginal series.

Interradial: Between arms.

Lamella: Thin vertical platelet.

Lateral: Along sides, between actinal and abactinal.

Lateral furrow: Groove between superomarginals and inferomarginals.

Madreporite: Stony sieve-plate at terminus of water vascular system, on aboral surface, between margin and center of disc.

Mammilliform: Nipple-shaped.

Marginals: One or two series of plates bordering arms and disc, around periphery.

Mouth frame: Ossicles surrounding mouth opening.

Oral: Surface on which mouth is located.

Ossicle: Plate, or skeletal element.

Papilliform pedicellaria: Raised or elevated pedicellaria.

Papula: Thin respiratory evagination of the body wall which emerges between ossicles.

Papular pore: Pore through which papula projects.

Paxilla: Aboral plate drawn up into a column which is usually crowned with spinules.

Paxillate: Surface covered with paxillae.

Paxilliform: Shaped like a paxilla.

Pedicellaria: Small calcareous "pincher," of which there are various types, used mostly to remove particulate matter from surface of starfish.

Pentagonal: Five-sided, without distinction between disc and arms.

Podia: Tube feet.

Radial furrow: Furrow on actinal surface running from ambulacral groove to margin.

Radius: Long radius (R), distance from center of disc to tip of arm; short radius (r), radius of disc.

Reticulate: Netlike, a network.

Sessile pedicellaria: Pedicellaria resting directly on surface, not raised or sunken.

Spine: Sharp, calcareous projection resting on underlying plate.

Spinule: Very fine small spine.

Stellate: Radiating, starlike.

Sucker: Disc or flattened tip at end of tube foot.

Superomarginal: Plate of upper series of marginals.

Sutural groove: Groove between adjacent marginals.

Terete: Cylindrical, tapering.

Tessellate: Mosaic of small fairly regular plates.

Tridentate: With three teeth or valves.

Triseriate: In a series of three.

Tubercle: Calcareous projection shorter and thicker than spines.

Valvular pedicellaria: Pedicellaria with two valvelike pieces.

Wart: Calcareous projection larger than granule but smaller than tubercle.

KEY TO THE ORDERS OF NORTH CAROLINA ASTEROIDEA

- | | |
|---------------------------------------|-------------------|
| 1. Podia without suckers..... | 2 |
| Podia with suckers..... | 3 |
| 2. Superomarginals absent.... | Platyasterida (I) |
| Superomarginals present.... | Paxillosida (II) |
| 3. Marginals conspicuous..... | Valvatida (III) |
| Marginals inconspicuous or absent.... | 4 |
| 4. Pedicellariae absent..... | Spinulosida (IV) |
| Pedicellariae present..... | Forcipulatida (V) |

I. Key to the Species of Platyasterida

- | | |
|---|----------------------------|
| 1. Arms with wide transverse bands or blotches of black or brown... <i>Luidia alternata</i> | |
| Arms without transverse color bands.... | 2 |
| 2. Inferomarginals with three spines, upper one much larger than others (young specimens may have only two) | <i>Luidia elegans</i> |
| Inferomarginals with two spines..... | 3 |
| 3. Paxillae quadrangular, skeleton compact | <i>Luidia clathrata</i> |
| Paxillae stellate, skeleton fragile | <i>Luidia bernasconiae</i> |

II. Key to the Species of Paxillosida

- | | |
|--|------------------------------|
| 1. Superomarginals separated by gap..... | <i>Ctenodiscus crispatus</i> |
| Superomarginals broadly in contact.... | 2 |
| 2. Marginal fringe of flattened, rectangular spines, usually not projecting much beyond margin; large size. <i>Tethyaster vestitus</i> | |
| Marginal fringe of acute spines forming conspicuous border; moderate size.. | 3 |
| 3. Rays long, slender; superomarginals small, numerous..... | 4 |
| Rays not very long, robust; superomarginals large, few..... | 5 |

4. Paxillar spinules long, slender, movable; paxillae in irregular narrow transverse rows ----- *Astropecten americanus*
 Paxillar spinules small, clavate, fixed; paxillae in regular wide transverse rows ----- *Astropecten nuttingi*
5. All superomarginals without spines or tubercles ----- *Astropecten nitidus*
 Some superomarginals with spines or tubercles ----- 6
6. Stout acute spine on at least two inter-radial superomarginals.
Astropecten duplicatus
 Small obtuse spine on distal half to three quarters of superomarginals.
Astropecten articulatus

III. Key to the Species of Valvatida

1. Dorsal skeleton reticulate ----- 2
 Dorsal skeleton tabulate or paxillate ---- 4
2. Disc large, arms short ---- *Oreaster reticulatus*
 Disc small, arms long ----- 3
3. Arms triangular in cross section, tapering to acute ends ----- *Narcissia trigonaria*
 Arms cylindrical, with rather blunt ends ----- *Linckia bowvieri*
4. Dorsal skeleton paxillate -- *Odontaster hispidus*
 Dorsal skeleton tabulate ----- 5
5. Large heavy subacute spines on dorsal surface ----- *Goniaster americanus*
 No spines on dorsal surface ----- 6
6. Rr more than three to one; arms long, acute ----- *Mediaster bairdii*
 Rr less than two to one; arms short, blunt ----- 7
7. Papulae few, in rows along each radius; marginals covered with granules.
Plinthaster dentatus
 Papulae numerous, scattered among plates; marginals usually bare of granules, at least in center -- *Peltaster planus*

IV. Key to the Species of Spinulosida

1. Arms five ----- 2
 Arms six to eight ----- *Solaster caribbaeus*
2. Disc broad, with broadly based arms ----
Porania insignis
 Disc small, with long, cylindrical arms -- 3

3. Dorsal and marginal plates quadrangular, overlapping at corners, in longitudinal rows ----- *Thyraster serpentarius*
 Dorsal and marginal plates not quadrangular, not overlapping at corners, not in regular rows ----- 4
4. Small spines in groups or along ridges; papulae on both surfaces -----
Henricia sanguinolenta
 One or few coarse spines at nodes; no papulae on oral surface ----- 5
5. Two adambulacral spines -----
Echinaster spinulosus
 Three adambulacral spines ----- 6
6. Aboral spines in about five irregular rows ----- *Echinaster sentus*
 Aboral spines in 9 to 11 rows -----
Echinaster brasiliensis

V. Key to the Species of Forcipulatida

1. Aboral surface with short blunt spines (tubercles) ----- 2
 Aboral surface with slender spines, at least along margins ----- 3
2. Arms somewhat flattened, sharply tapering, with distinct median row of aboral plates ----- *Asterias vulgaris*
 Arms inflated, blunt at tip, no distinct median row of aboral plates *Asterias forbesii*
3. Aboral spines with dense wreath of small pedicellariae ----- 4
 Aboral spines without dense wreath of small pedicellariae ----- 5
4. With five arms ----- *Asterias tanneri*
 With ten to twelve arms -- *Coronaster briarius*
5. Aboral plates arranged in definite rows, one spine to each plate -----
Coscinasterias tenuispina
 Aboral plates not arranged in definite rows, more than one spine to each plate 6
6. Aboral surface with minute spines; arms seven to nine -- *Stephanasterias gracilis*
 Aboral surface with conspicuous spines; arms five ----- *Leptasterias tenera*

DESCRIPTION OF SPECIES

The following descriptions are given merely as supplements to the keys and additional aids to identification. It is not the purpose of this paper to give a complete systematic treatment of the North Carolina species of Asteroidea, and diag-

noses and descriptions of higher taxa have, therefore, not been included. The species descriptions have been kept as simple as possible for quick identification.

The preceding keys are strictly artificial, and their usefulness is, therefore, limited to the Continental Shelf off North Carolina.

PLATYASTERIDA

In North Carolina the Order Platyasterida is represented by one genus and four species. Three species have "southern" affinity and are not abundant. Distribution of *Luidia clathrata* is far wider than that of other species in this genus (fig. 5).

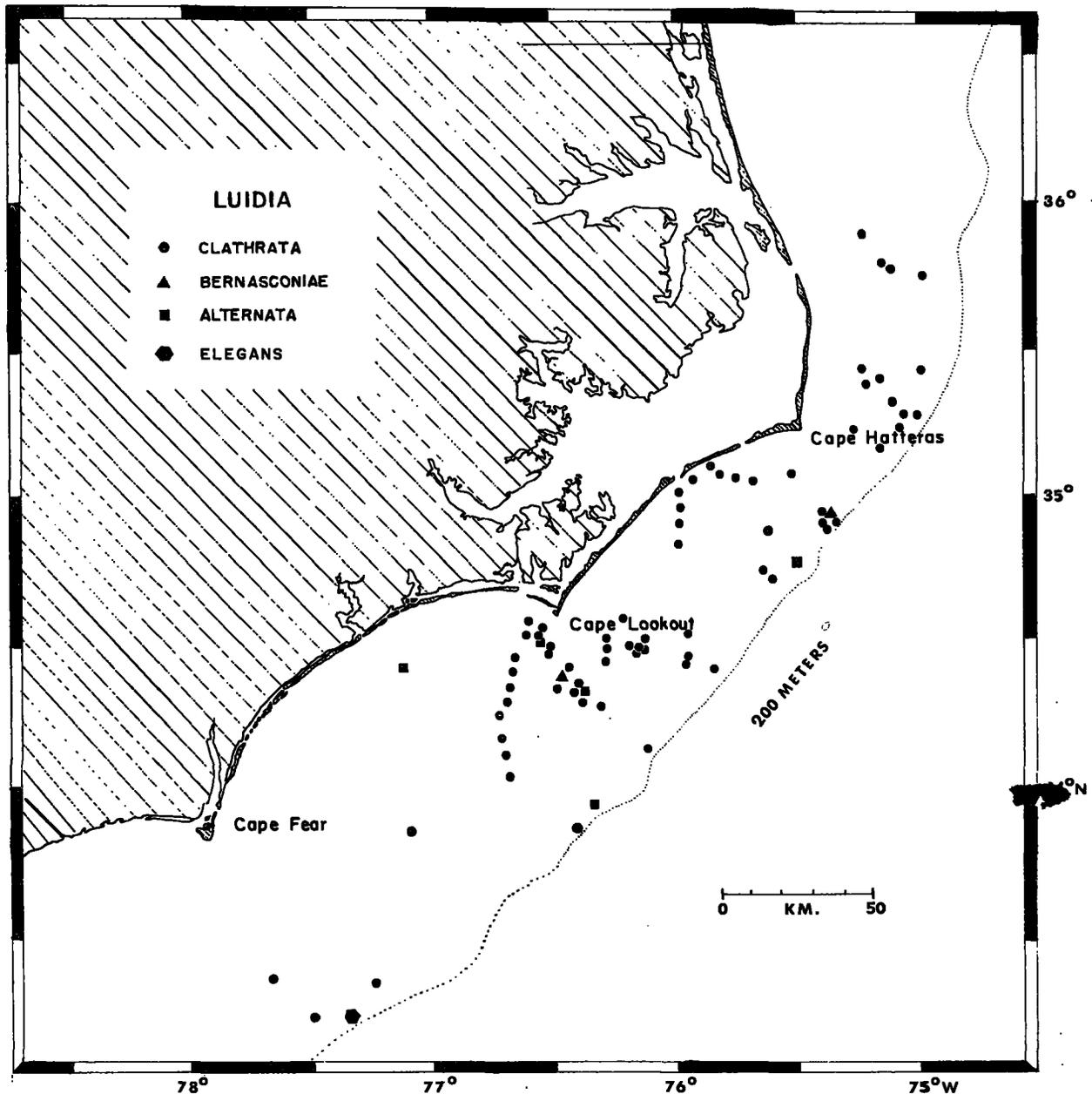


FIGURE 5.—Distribution and relative abundance of four species of *Luidia*. Many of the numerous stations at which *L. clathrata* was collected have been omitted.

Luidia alternata (Say)

Synonymy:

Asterias alternata Say, 1825.

Luidia alternata: Lütken, 1859.

Luidia variegata Perrier, 1876.

Description:

Rays five, long and fragile. Aboral paxillae with 10 to 16 slender, acute spinules surrounding stouter central 1 or 2; some paxillae much

larger than others, with large central spine, especially along margins of arms, and scattered on disc. Two to four lateral rows of paxillae larger than those on median portion of arm. Inferomarginals with two long acute upper spines and about three long spines and many small acute ones on lower side. Adambulacrals with three or four spines. $Rr=8:1$. Color gray or light brown with broad irregular bands of black or dark brown across arms; tube feet frequently bright orange.

Range:

Southeast coast of the United States to Brazil, 10 to 200 m. Although not abundant, *L. alternata* is occasionally taken in dredges and trawls. Pearse and Williams (1951) reported it in North Carolina waters from reefs off New River Inlet.

Luidia bernasconiae A. H. Clark, 1945

Description:

Rays five, very long and narrow. Adambulacral spines two, inner one flattened laterally, recurved. One or two large, acute or subacute spines on outer rows of dorsal paxillae, colored brown and white. Two large, less acute white spines on inferomarginals; many small sharp spines on marginals and in grooves between marginals. Paxillae in center of rays crowded, irregular, small; single outer row of paxillae dark, next two rows large, light, often forming distinct band down each side of arm. These three rows of paxillae may bear short, stumpy tridentate sessile pedicellariae, and some bear a large central spine. Paxillae with 5 to 10 clavate spinules surrounding central paxillar boss with larger, thicker spinule. Large tridentate pedicellariae on columnar interactinals, between adambulacrals and inferomarginals, especially proximally (none distally). Marginal spines are long and erect, giving a thorny appearance. $Rr=7:1$. Color dark gray or brown above, white below.

Range:

Previously recorded only off Georgia (Clark, 1945). In North Carolina it has been taken several times, in depths of 20 to 110 m.

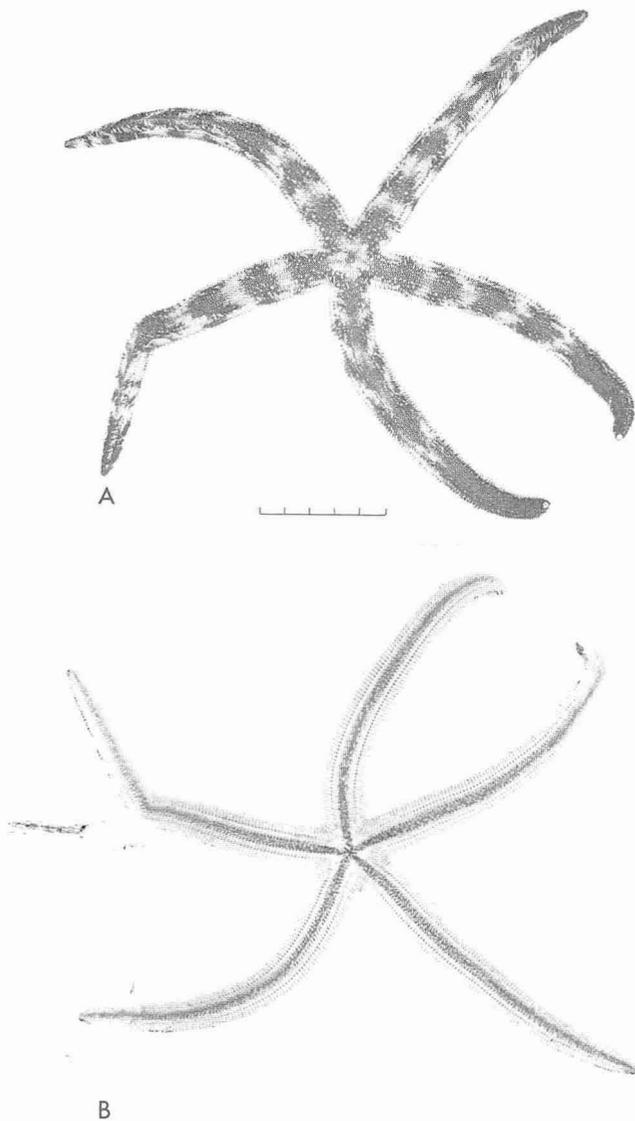
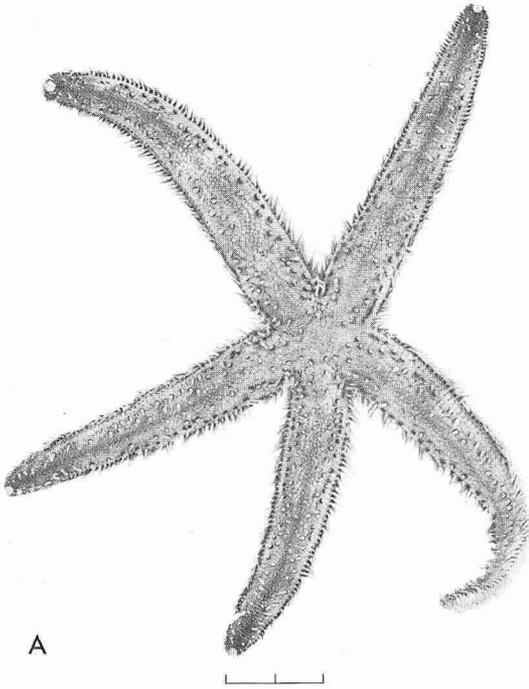
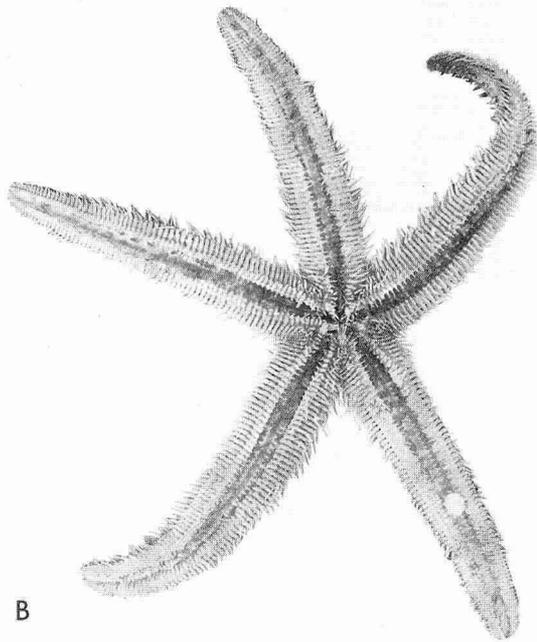


FIGURE 6.—*Luidia alternata*. A, aboral; B, oral. 5 cm. indicated.



A



B

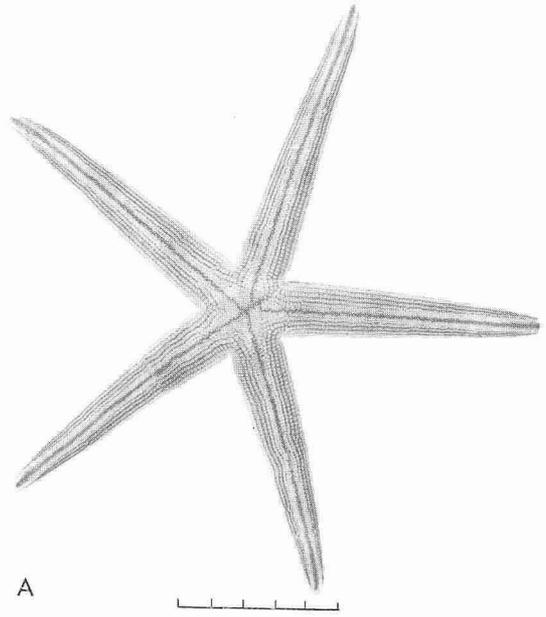
FIGURE 7.—*Luidia bernasconiae*. A, aboral; B, oral. 2 cm. indicated.

***Luidia clathrata* (Say)**

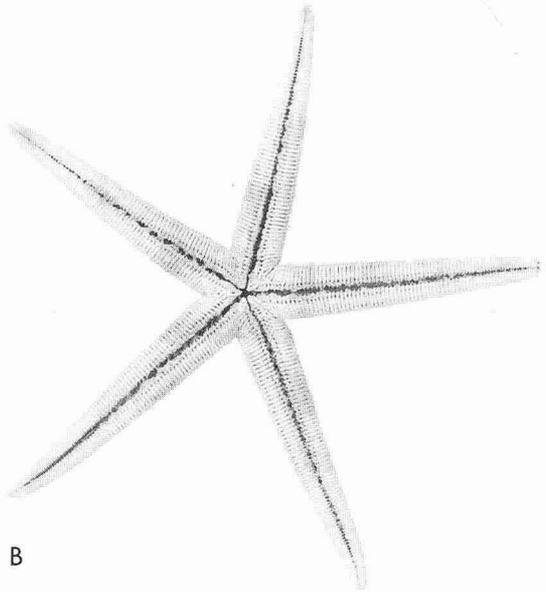
Synonymy:

Asterias clathrata Say, 1825.

Luidia clathrata: Lütken, 1859.



A



B

FIGURE 8.—*Luidia clathrata*. A, aboral; B, oral. 5 cm. indicated.

Description:

Rays five, long, straplike. Aboral surface flattened, regularly tessellated; paxillae quadrangular, 10 to 12 close, fairly regular rows, lateral rows distinctly larger than median rows. Paxillae covered with numerous short, coarse spinules. Inferomarginals with two

acute spines around bases. $Rr=6:1$. Color commonly gray or blue-gray, but may be salmon, rose, or light brown.

Range:

New Jersey to Brazil, 10 to 175 m. This species is the most common member of the genus in North Carolina and apparently the only one that is found north of Cape Hatteras. South of Cape Hatteras it is second only to *Astropecten articulatus* in abundance and is often taken with *Astropecten*. It is found in all three biotic provinces and in depths to 175 m., but is most abundant in the Carolinian Province in depths of 9 to 110 m.

***Luidia elegans* Perrier, 1876**

Description:

Rays five; aboral paxillae stellate, crowded, smallest in median portion of rays, larger near margins, with short central spinule and 6 to 10 marginal spinules not or scarcely enlarged at tip, giving very uniform appearance to paxillar area. Inferomarginals with two to three (three in fully grown specimens) large spines. Bivalved pedicellariae often present on actinal side. $Rr=7:1$. Color orange above, lighter below.

Range:

Cape Hatteras to Barbados, 95 to 267 m. Not common in North Carolina.

PAXILLOSIDA

In North Carolina, *Astropecten*, with five species, is the most conspicuous of the three genera in the Order Paxillosida. *A. articulatus* and *A. americanus* are the most abundant species. The relative abundance and distribution of the various species of *Astropecten* are indicated in figure 10. Although *A. americanus* and *A. articulatus* are very abundant, they apparently are not competitors for the same space. The former occurs mainly in the deeper waters of the shelf north of Cape Hatteras, and the latter is most abundant south of the Cape. The two species have not been taken in the same dredge haul. *A. duplicatus* has occasionally been found at the same station with *A. articulatus*, however, and *A. nitidus* and *A. nuttingi* have been taken together near the edge of the shelf east of Frying Pan Shoals.

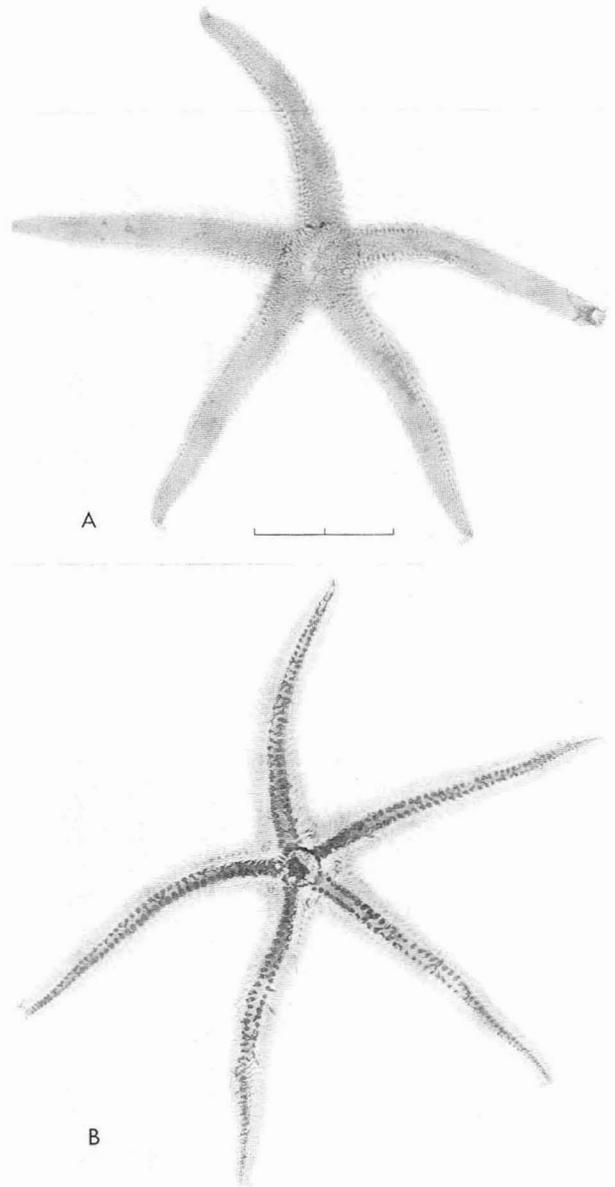


FIGURE 9.—*Luidia elegans*. A, aboral; B, oral. 2 cm. indicated.

***Ctenodiscus crispatus* (Retzius)**

Synonymy:

Asterias crispata Retzius, 1805.

Ctenodiscus crispatus: Duben and Koren, 1846.

Ctenodiscus australis Lütken, 1871.

Ctenodiscus krausei Ludwig, 1886.

Ctenodiscus procurator Sladen, 1889.

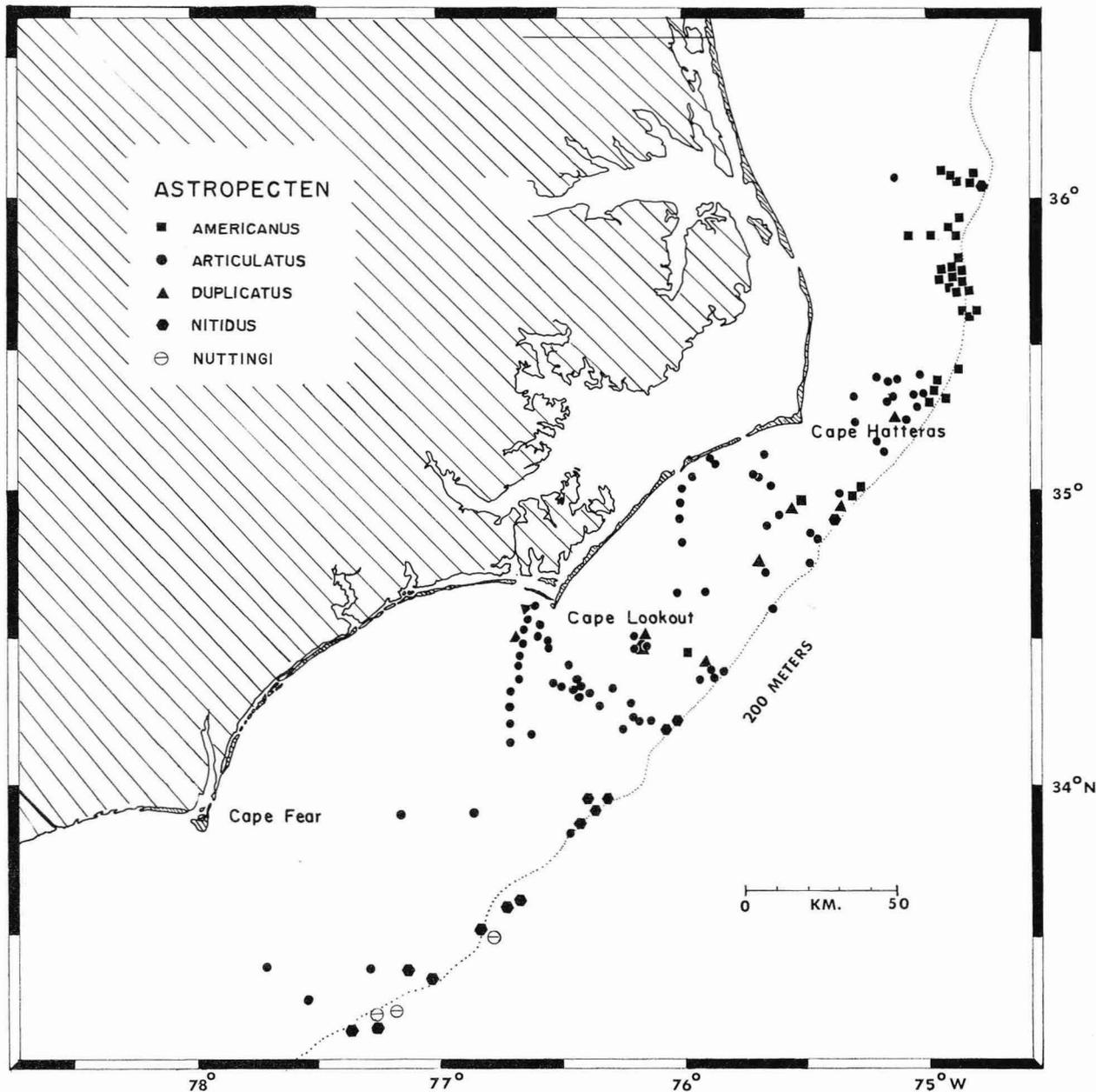


FIGURE 10.—Distribution and relative abundance of five species of *Astropecten*. Many of the numerous stations at which *A. articulatus* was collected have been omitted.

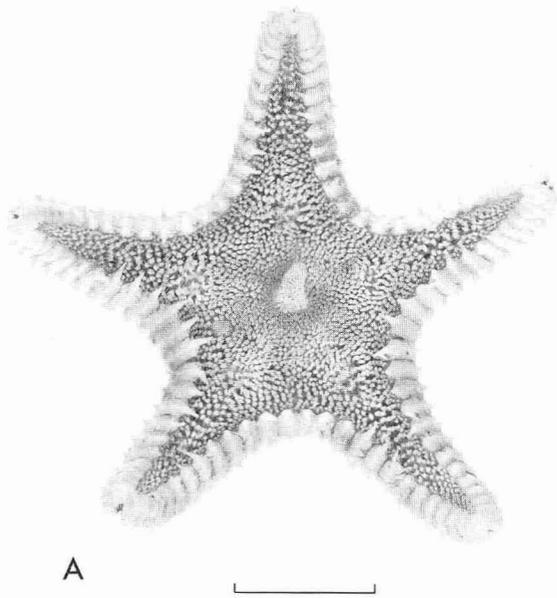
Description:

Five arms; body form variable, from almost pentagonal to nearly star-shaped. Aboral surface of typical paxillae; podia devoid of suckers. Conspicuous marginal plates, between each pair of which are simplified cribriform organs each in the form of a groove containing a few lamellae, which continue as simple

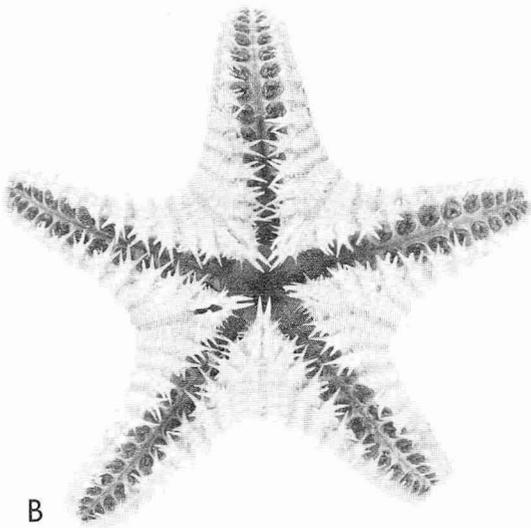
channels between plates of oral side up to ambulacral grooves. Lacks intestine, intestinal caeca, and anus. Epiproctal cone present. Rr= 1.6–3.1:1. Color yellowish.

Range:

Circumboreal; in the Pacific, extends down to Chile; 55 to 1,800 m. Rare in North Carolina.



A



B

FIGURE 11.—*Ctenodiscus crispatus*. A, aboral; B, oral. 1 cm. indicated.

***Tethyaster vestitus* (Say)**

Synonymy:

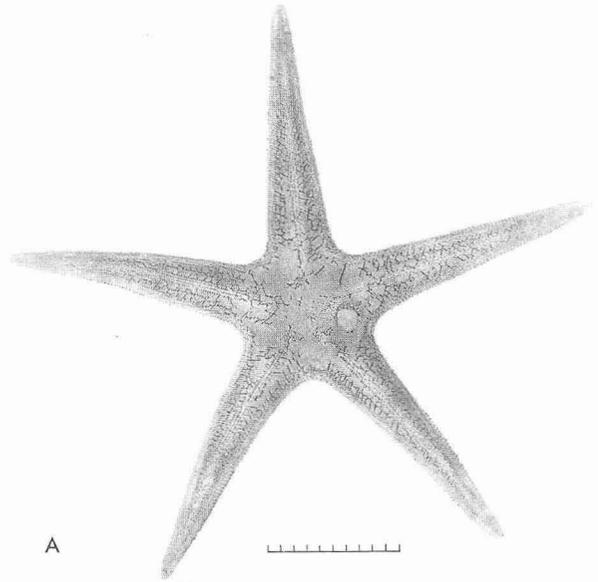
Asterias vestita Say, 1825.

Astropecten vestitus: Lütken, 1859.

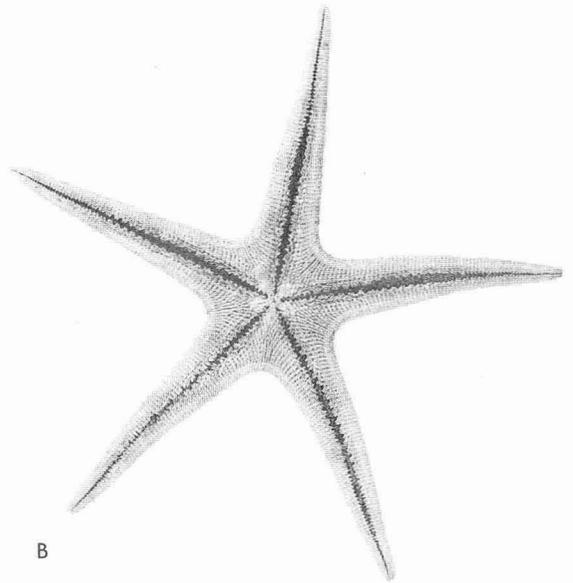
Sideriaster (?) *vestitus*: Verrill, 1914.

Description:

Form broadly stellate, with very large disc.
Arms five. Aboral surface closely covered with



A



B

FIGURE 12.—*Tethyaster vestitus*. A, aboral; B, oral. 10 cm. indicated.

uniform stellate paxillae. Upper marginals granulated, small, entirely lateral. Aboral interradial areas large, with numerous granulated plates. Madreporite very large, round, flat. Papular pores over entire aboral surface, about six around each plate. Adambulacrals with large median compressed spine, with two to three erect flattened spines on each side of furrow series; stout spines on actinal side,

with single or double row of shorter flat spines behind it. $Rr=4:1$. Color bright red or orange.

Range:

New Jersey to Venezuela, 37 to 293 m. North Carolina specimens were taken near the outer edge of the shelf.

Astropecten americanus Verrill

Synonymy:

Archaster americanus Verrill, 1880.

Astropecten americanus: Verrell, 1894.

Description:

Body flat and thin; rays long, slender, tapering to acute tips. Aboral paxillar area about four times as wide as adjacent margin at base of ray. Paxillae small, with 6 to 10 elongate slender spinules surrounding central 1 or 2, in narrow transverse rows, rather openly spaced, so that papular pores are visible. Superomarginals small, numerous, usually broader than long, with deep, wide fasciolated grooves between; plates flat or concave. Inferomarginals project slightly beyond superomarginals, bear two slender, flattened, acute spines and sometimes a small papilliform pedicellaria; underside with small acute spines and spinules. Adambulacrals with three to five slender furrow spines. $Rr=5.5:1$. Color dark red or reddish brown.

Range:

East coast of the United States, 55 to 540 m. In North Carolina, *A. americanus* is limited largely to deeper waters of the outer edge of the shelf north of Cape Hatteras, where it appears to be the dominant asteroid. Bottom photographs show it to be abundant (fig. 14). Relatively few have been taken south of Cape Hatteras, where *A. articulatus* is the dominant *Astropecten*.

Astropecten articulatus (Say)

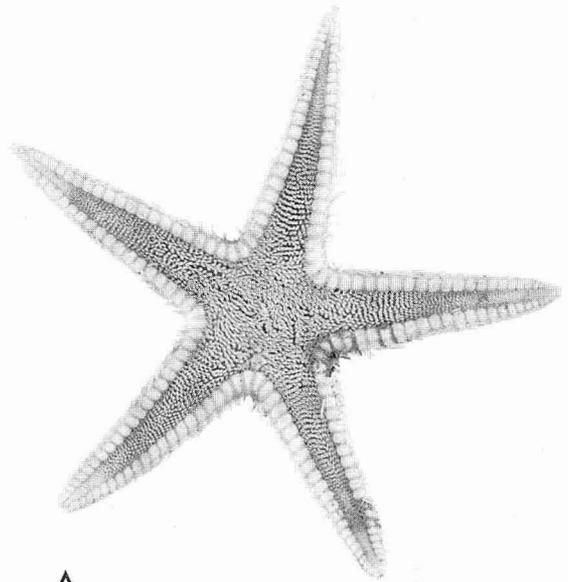
Synonymy:

Asterias articulatus Say, 1825.

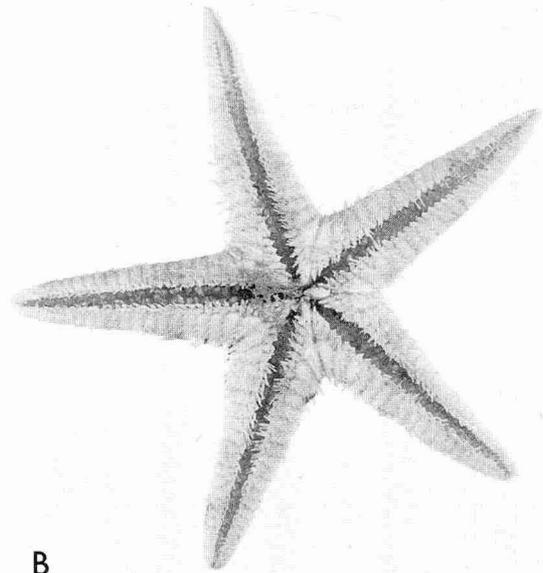
Astropecten articulatus: Mueller and Tro-schel, 1842.

Description:

Thick disc, five robust arms, with large stout superomarginals densely granulated. On distal half to three-quarters of rays, superomarginals sometimes bear a single small, obtuse spine on outer convex surface. Inferomargin-



A



B

FIGURE 13.—*Astropecten americanus*. A, aboral; B, oral. 1 cm. indicated.

als with two short, flattened marginal spines, side by side. Adambulacrals triseriate. Aboral paxillae stellate, crowded, with six to eight short clavate spinules surrounding central one

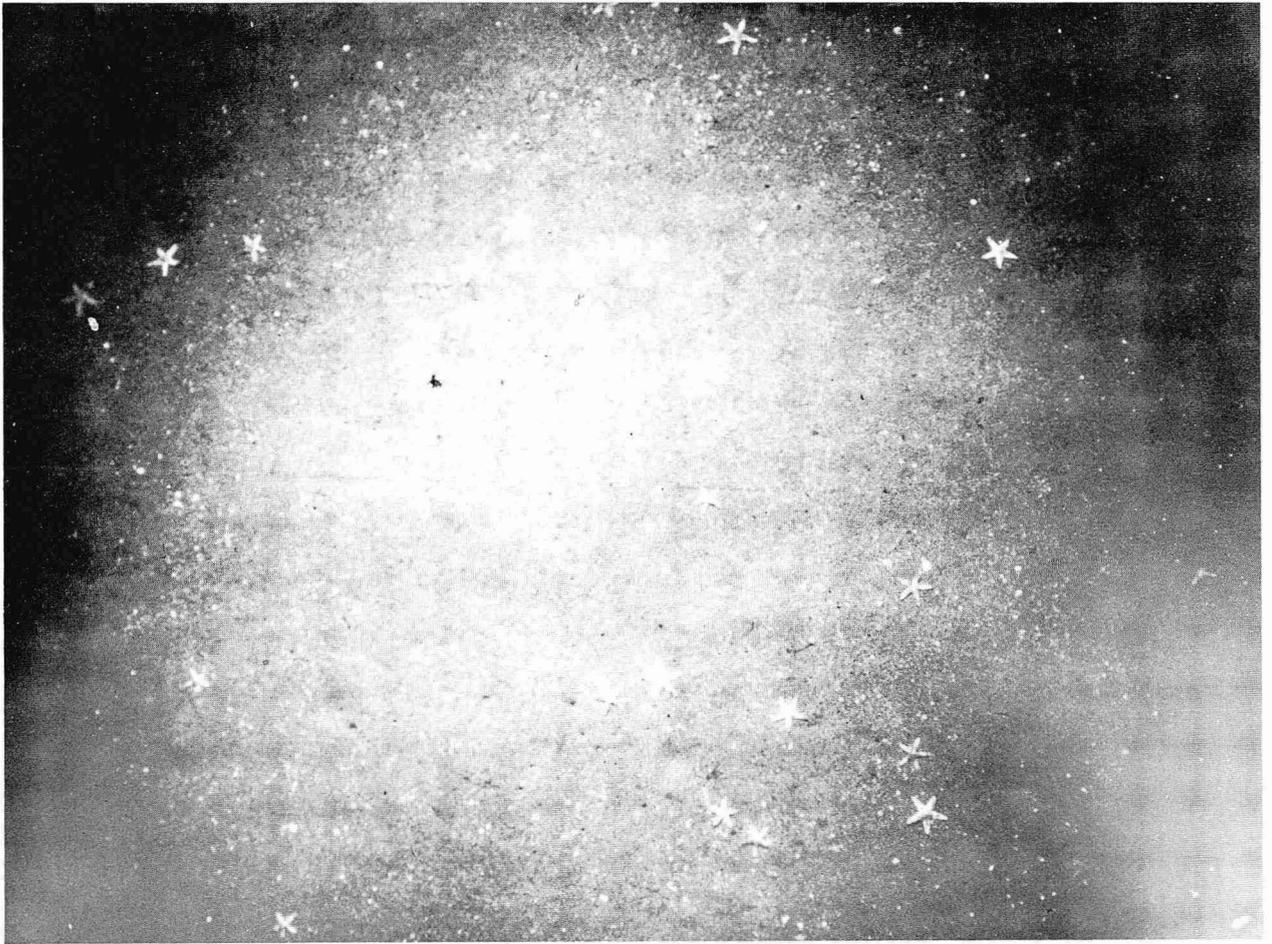


FIGURE 14.—Photograph of sea floor showing abundance of *Astropecten americanus* at 165 m., northeast of Cape Hatteras. The area shown is about 4 m.²

to two. Rr=4-6.5:1. Color of paxillar area blue or purple, marginals white to orange.

Range:

New Jersey to Uruguay, 9 to 165 m. This is probably the most common sea-star in North Carolina, especially in Onslow and Raleigh Bays. Its abundance decreases north of Cape Hatteras. Trawlers take it in large numbers, frequently with *Luidia clathrata*. Although often found near the outer edge of the shelf, it is much more abundant in 18 to 110 m., where it glides over the sandy substrate and feeds on the numerous small organisms that abound there. Wells and Gray (1961) reported 93 species of small mollusks from the stomachs of 125 *A. articulatus*.

Astropecten duplicatus Gray

Synonymy:

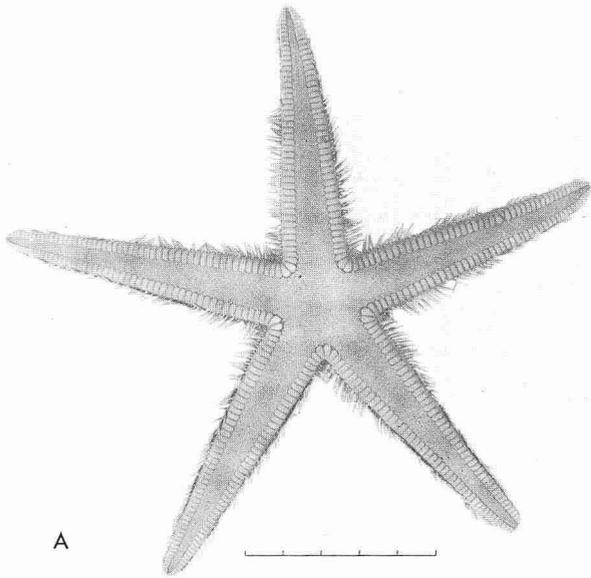
Astropecten duplicatus Gray, 1840.

Astropecten valenciennii Mueller and Tro-schel, 1842.

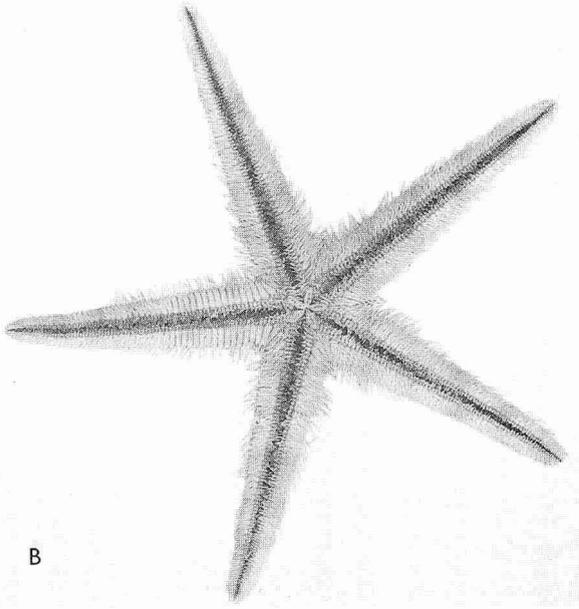
Astropecten variabilis Lütken, 1859.

Description:

Form stellate; rays five, angular, regularly tapered to narrow tips, high on sides at base. Superomarginals form thick border, elevated above paxillar area, with stout spine on first seven plates of each arm; spines on first two plates are largest. Inferomarginals project beyond superomarginals, forming lateral furrow felted with fine spinules. Surface of marginals granular. Inferomarginals with two to



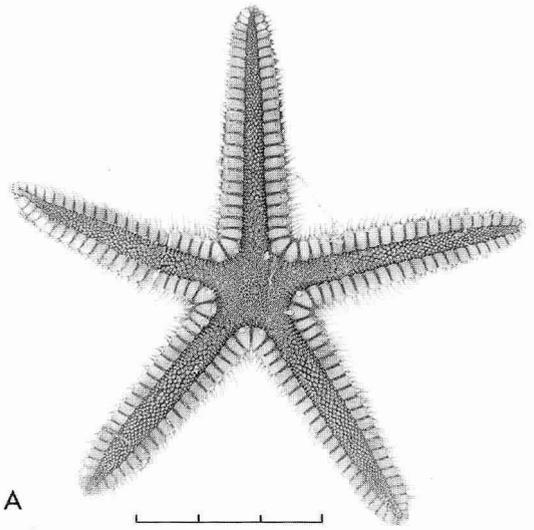
A



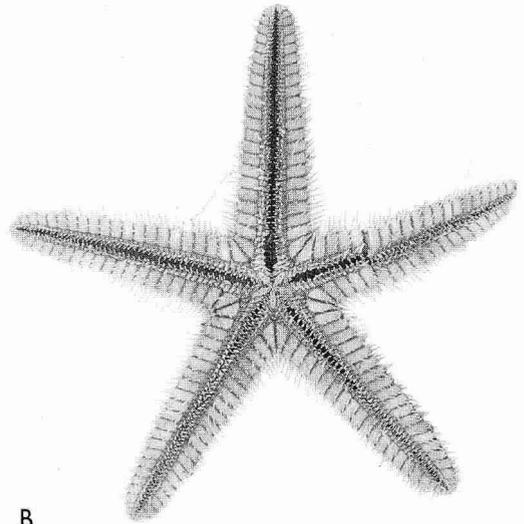
B

FIGURE 15.—*Astropecten articulatus*. A, aboral; B, oral. 5 cm. indicated.

three short, flattened, subacute spines. Aboral paxillae with 8 to 10 long clavate or capitate spinules surrounding 1 to 3 central ones. At base of rays, paxillae may have 12 to 16 spinules surrounding 4 to 8 central ones. Paxillae of generally uniform size and irregular arrangement. $Rr=5.3:1$. Color reddish brown or gray.



A



B

FIGURE 16.—*Astropecten duplicatus*. A, aboral; B, oral. 3 cm. indicated.

Range:

North Carolina to Brazil, 5 to 185 m. Although much less abundant, this species is sometimes collected with *A. articulatus*. It occurs mainly south of Cape Hatteras.

Astropecten nitidus Verrill, 1915

Description:

Body thick, stellate, with five short, acute rays. Superomarginals wide, convex, with deep transverse sutural grooves forming wide

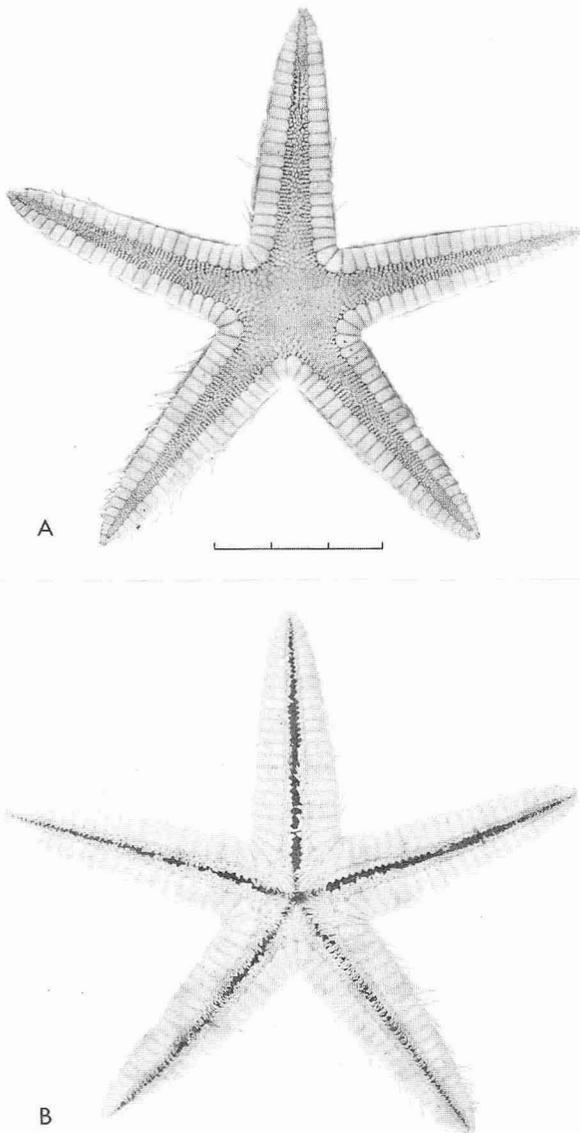


FIGURE 17.—*Astropecten nitidus*. A, aboral; B, oral. 3 cm. indicated.

prominent border, without spines or spinules, covered with granules. Aboral paxillar area narrow, less than twice width of adjacent marginals. Paxillae not very small, with 10 to 15 small, stellate, clavate spinules surrounding 1 to 2 central ones. Inferomarginals with two long, tapered, acute marginal spines, numerous fine, acute spinules, and two transverse rows of small acute spines on underside. $Rr=3.7:1$. Color light brown or cream, with blotches of rose pink.

Range:

North Carolina to Florida, 50 to 225 m. In North Carolina this species appears to be limited to the edge of the shelf, in 145 to 210 m. It is apparently more abundant between Cape Lookout and Cape Fear than between Cape Lookout and Cape Hatteras.

***Astropecten nuttingi* Verrill, 1915**

Description:

Rays five, shape regularly stellate, flat and thin. Epiproctal cone usually prominent. Marginals small, covered with tiny, fine spinules; may bear a short, tapered spine on upper side of superomarginal. Inferomarginals reach to adambulacrals and are covered with small acute spines, with two to three long somewhat compressed marginal fringe spines. Paxillae small, equal, even, arranged in obliquely transverse rows, with 0 to 10 short slender spinules around crown and 1 to 2 in center of crown. Adambulacrals with marginal row of three slender spines, central one slightly curved and compressed. Madreporite small, usually concealed by paxillae. $Rr=5:1$. Color reddish, with deep red median line on each arm.

Range:

North Carolina to Florida and the Bahamas, 165 to 412 m. Although the least abundant of the North Carolina *Astropectens*, it is not uncommon along the 180- to 200-m. contour east of Cape Fear.

VALVATIDA

None of the species in this group can be considered common in North Carolina. Some are taken only rarely.

***Oreaster reticulatus* (Linnaeus)**

Synonymy:

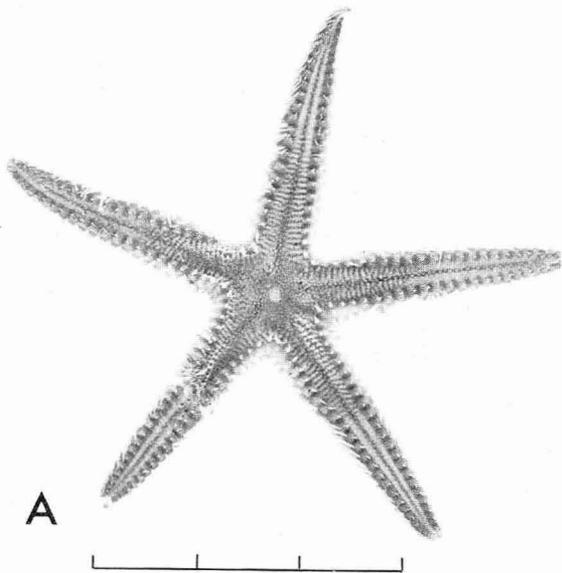
Asterias reticulatus Linnaeus, 1758.

Oreaster reticulatus: Mueller and Troschel, 1842.

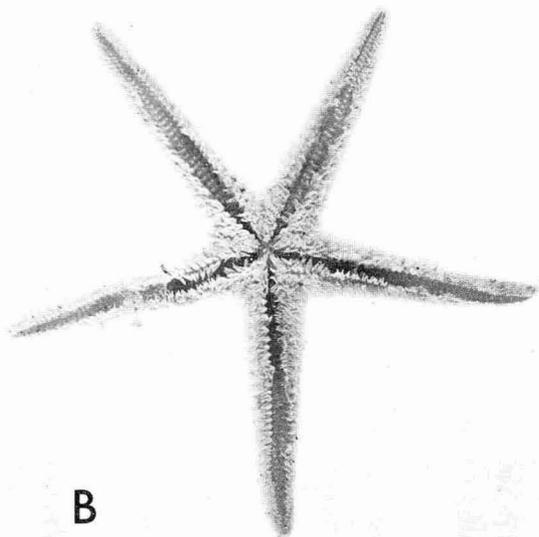
Pentaceros reticulatus Agassiz, 1877.

Description:

Large, heavy stellate form, disc arched, inflated; arms four to six (normally five), short, acute. Skeleton reticulate, plates bar-shaped, with short, stout, conical spine at nodes. Marginals granular, covered with skin, each with a large conical spine. Papular areas conspicu-



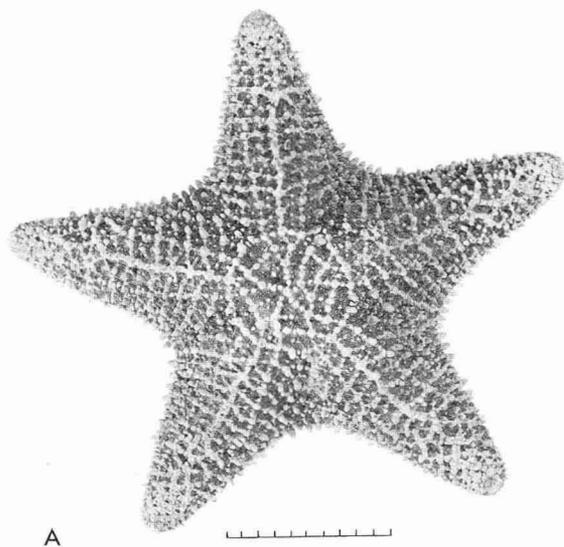
A



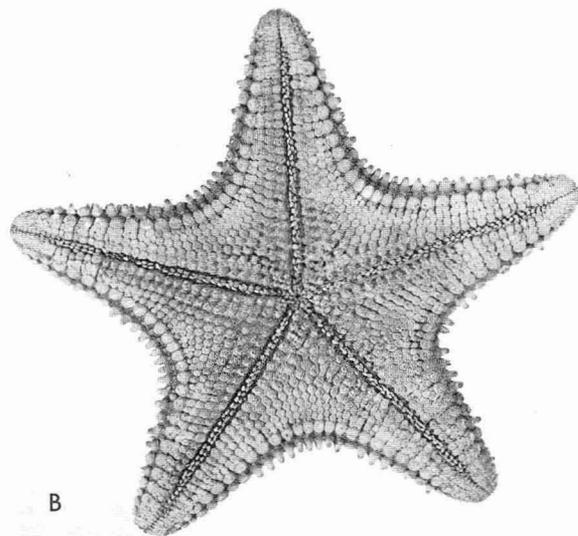
B

FIGURE 18.—*Astropecten nuttingi*. A, aboral; B, oral. 3 cm. indicated.

ous. Aboral surface covered by thick mosaic of plates with short stout central spine. Bivalved pedicellariae present. $Rr=2:1$. Color reddish brown, deep olive green, or yellowish orange.



A



B

FIGURE 19.—*Oreaster reticulatus*. A, aboral; B, oral. 10 cm. indicated.

Range:

North Carolina to Brazil; Cape Verde Islands. Shallow water. A tropical species taken only rarely in North Carolina.

***Narcissia trigonaria* Sladen, 1889**

Description:

Rays five, elongate, tapering to sharp end, triangular in cross section, with distinct median keel. Marginal plates well defined. Disc small,

Range:

North Carolina to Gulf of Mexico. A single specimen taken at the edge of the shelf off Cape Lookout in 210 m. constitutes a new record for North Carolina.

Linckia bouvieri Perrier, 1875

Description:

Disc small, rays five, long, slender, rounded. Primary plates of aboral surface large, irregular, rounded, tumid, five or more on disc. Plates become smaller, more numerous, and crowded distally. Papulae numerous, in clusters confined to aboral surface. Interactinal plates in two or more close rows. Inner adambulacral spines a close row of broad, somewhat flattened spines alternating with much smaller blunt, peglike spines; outer row of larger, stouter, more rounded spines arranged behind each small inner spine. Entire actinal and abactinal surface covered with fine granules. Rr=10:1. Color reddish fawn, primary plates and oral surface cream.

Range:

North Carolina to the West Indies, 73 to 360 m. Taken from near the edge of the shelf off Cape Lookout.

Odontaster hispidus Verrill, 1880

Description:

Form depressed, stellate, with broad disc. Rays five. Single, hyaline, recurved spine at apex of each jaw. Marginals only moderately developed, convex, separated by wide sutural grooves. Aboral plates elevated, capitate, with dense cluster of slender, elongate spinules. Interactinals (between adambulacrals and marginals) with stout, elongate, acute or subacute spinules. Large papular pores over most of radial areas and center of disc. Rr=2.2:1. Color pale salmon or yellowish.

Range:

Cape Cod to Florida, 30 to 875 m. Most of the stations from which this species has been taken are north of Cape Hatteras.

Goniaster americanus Verrill

Synonymy:

Goniaster americanus Verrill, 1871.

Pentagonaster semilunatus Perrier, 1876.

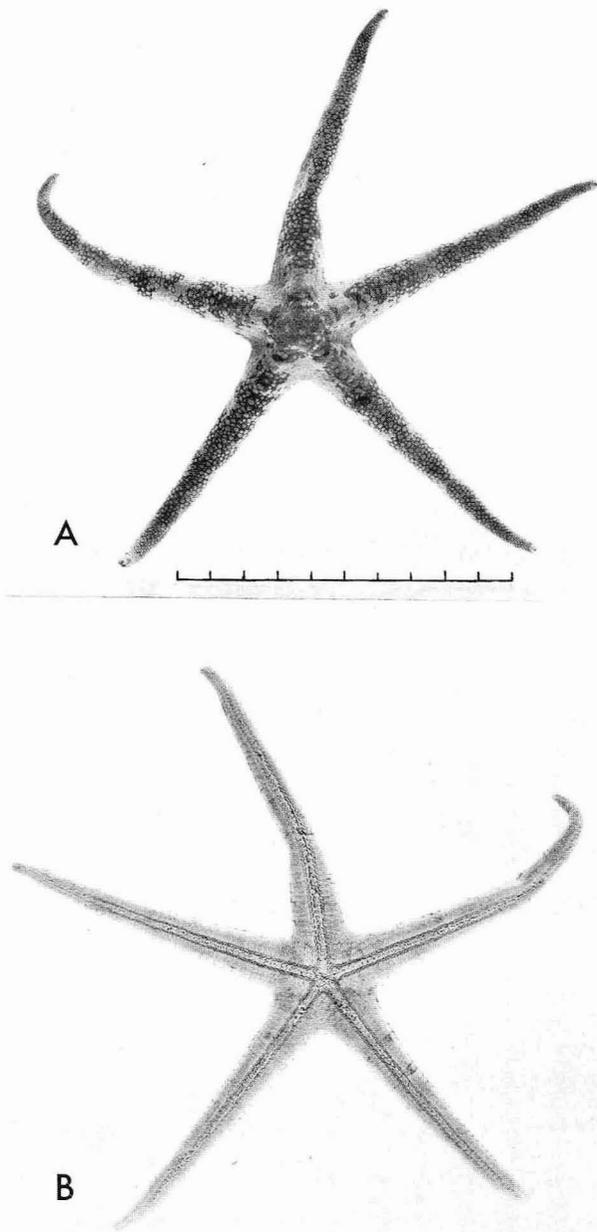


FIGURE 20.—*Narcissia trigonaria*. A, aboral; B, oral. 10 cm. indicated.

elevated. All plates covered with minute, uniform granules. Papulae single. Adambulacral spines in three series, broader at tip than at base, rather chisel shaped. Madreporite small, striated. Rr=6.7:1. Color creamy yellow with blotches of rusty red.

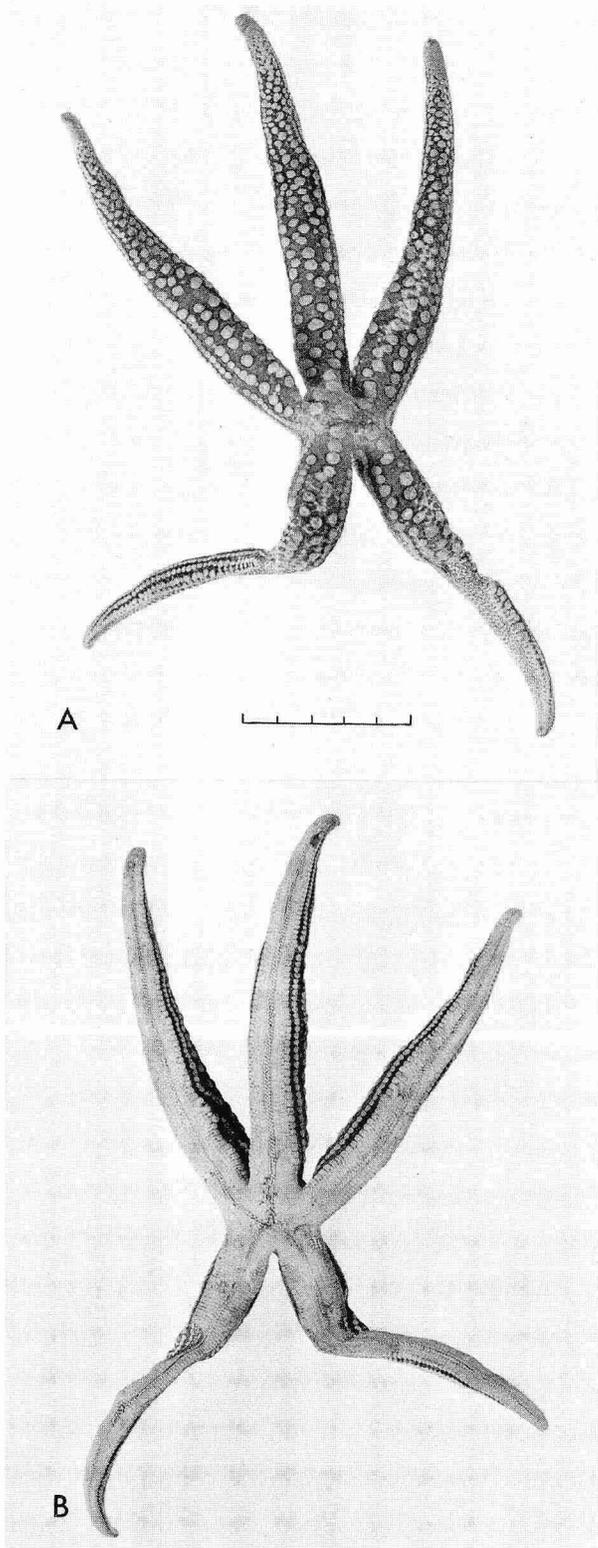


FIGURE 21.—*Linckia bouvieri*. A, aboral; B, oral. 5 cm. indicated.

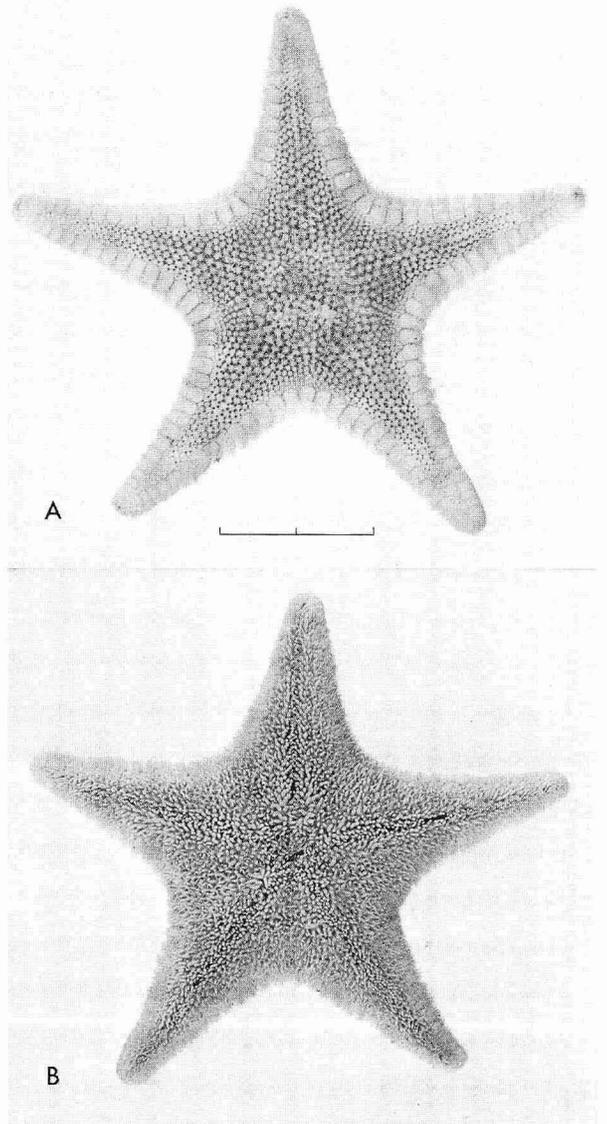


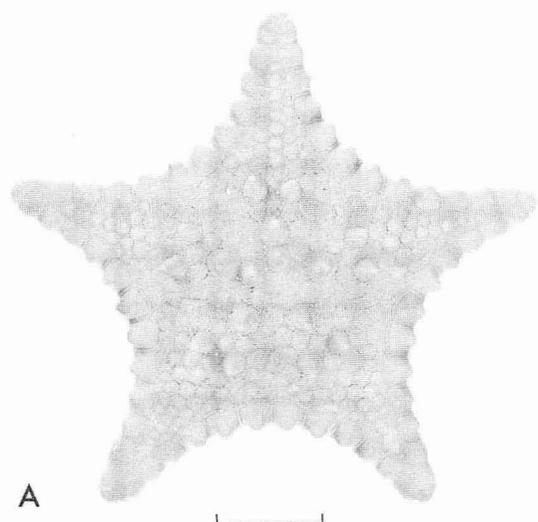
FIGURE 22.—*Odontaster hispidus*. A, aboral; B, oral. 2 cm. indicated.

Pentagonaster parvus Perrier, 1883.

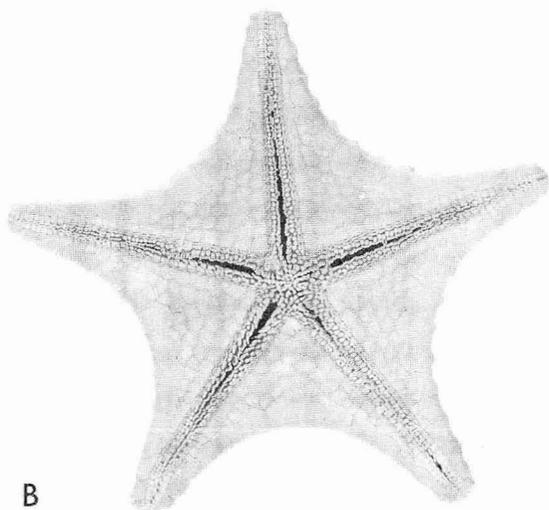
Phaneraster semilunatus: Perrier, 1894.

Description:

Broadly pentagonal, with concave sides and short rays. Aboral plates large, polygonal or circular, covered with granules, many with a large, conical spine. Superomarginals and inferomarginals about equal, large, convex, quadrangular, with rounded inner sides, six to nine on each side of ray (number depends on age). Numerous alveolar pedicellariae with spatulate blades on oral and aboral surfaces,



A



B

FIGURE 23.—*Goniaster americanus*. A, aboral; B, oral. 1 cm. indicated.

resting in depressions in plates. Adambulacrals with four stout, prismatic spinules in furrow series and, on distal adambulacrals, a single large obtuse spine outside the furrow series. $Rr=1.8:1$. Color dark brown on top, light brown underneath.

Range:

North Carolina to Florida and the West Indies, 55 to 235 m. Taken mainly from the edge of the shelf off Cape Lookout.

Mediaster bairdii Verrill

Synonymy:

Archaster bairdii Verrill, 1882.

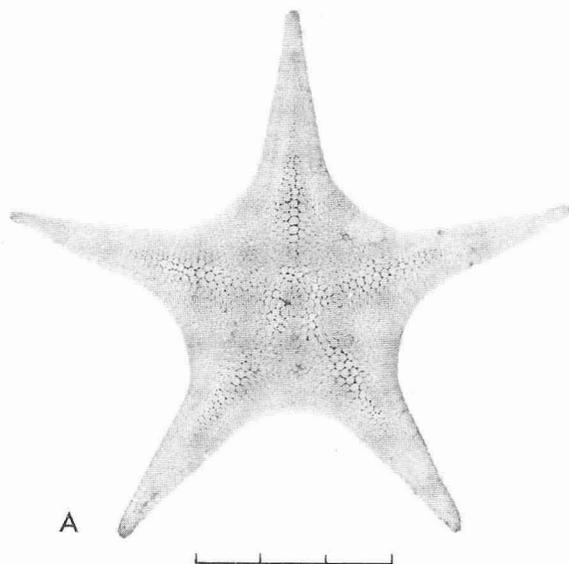
Mediaster stellatus Perrier, 1891.

Isaster bairdii: Verrill, 1895.

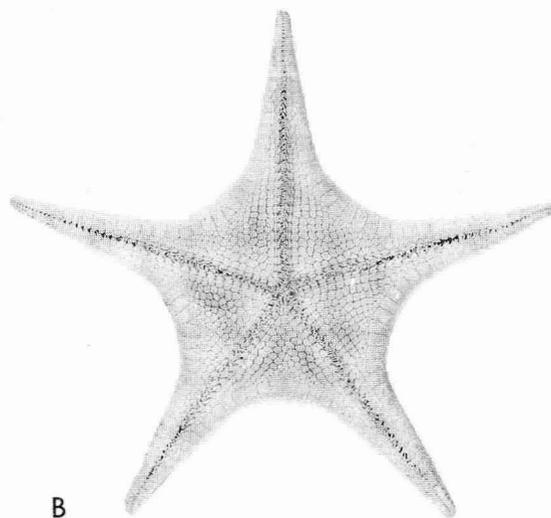
Mediaster bairdii: Verrill, 1899.

Description:

Form stellate, with broad flat disc and moderately long tapered rays. Marginals well devel-



A



B

FIGURE 24.—*Mediaster bairdii*. A, aboral; B, oral. 3 cm. indicated.

oped, granulated, numerous, upper and lower series nearly equal. Aboral plates longitudinally arranged, roundish, moderate in size, covered with rosette of short, obtuse spinules, sometimes with a broad sessile valvular pedicellaria. Adambulacrals with marginal row of three to seven slender spinules, sometimes with two to three bladed clavate pedicellariae. Actinal plates angular, in rows parallel to ambulacral grooves, covered with rosette of granules. $Rr=3.3:1$. Color brilliant red abactinally, salmon orange actinally.

Range:

Northeast coast of the United States, 90 to 360 m. Our only record is from the edge of the shelf off Cape Lookout.

***Plinthaster dentatus* (Perrier)**

Synonymy:

Pentagonaster dentatus Perrier, 1883.
Pyrenaster dentatus (Perrier), Verrill, 1899.
Plinthaster dentatus (Perrier), Fisher, 1911.

Description:

Form flat, more or less pentagonal, rays short. Marginals rather large, both series similar and paired. The distal inferomarginal behind the ocular plate smaller than the others; ocular plate somewhat pointed. Marginals closely covered with granules in young specimens, but with scattered clumps of granules in older specimens. Pedicellariae on adambulacrals rare, similar to granules, with short chisel-shaped blades. Adambulacral plates large, squarish; furrow spinelets in regular series, well separated from granules of actinal surface. Actinal plates polygonal, flat, crowded. Abactinal plates rounded, convex, usually with a border of granules. Papular pores not numerous confined to median radial area. $Rr=1.5:1$. Color bright orange or yellow.

Range:

North Carolina to Gulf of Mexico, 360 to 915 m. Recovered from a *Lophelia* coral reef on the slope southeast of Cape Lookout.

***Peltaster planus* Verrill**

Synonymy:

Pentagonaster planus Verrill, 1885.
Peltaster planus: Verrill, 1899.

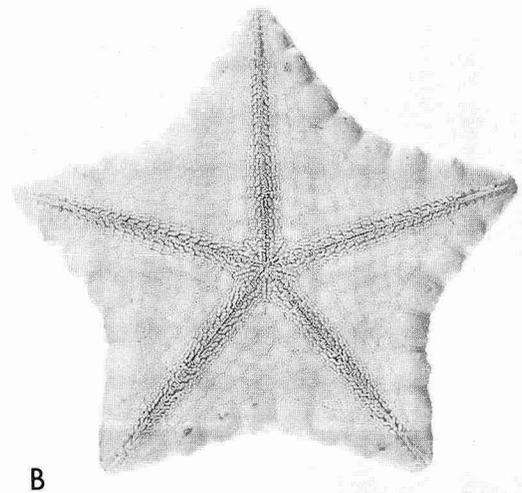
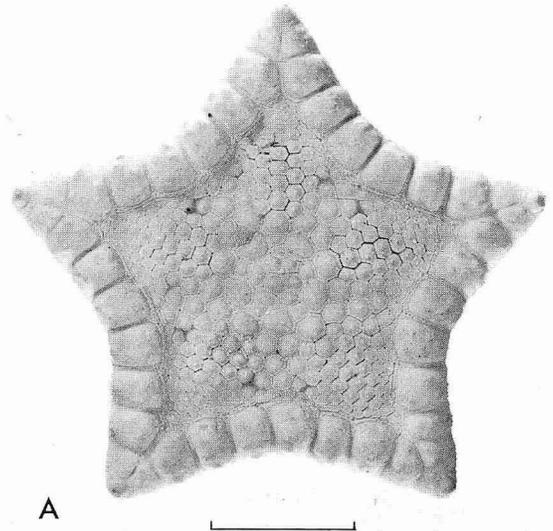


FIGURE 25.—*Plinthaster dentatus*. A, aboral; B, oral. 1 cm. indicated.

Description:

Body pentagonal, sides almost straight, rays five, triangular, obtuse. Marginals large, quadrangular, 14 in superomarginal series, 16 in inferomarginal series, covered with coarse granules (which easily rub off, sometimes leaving the superomarginals nearly bare). Aboral plates large, rounded or hexagonal, with many smaller secondary plates interspersed. All covered with rather uniform coat of granules. Actinal plates large,

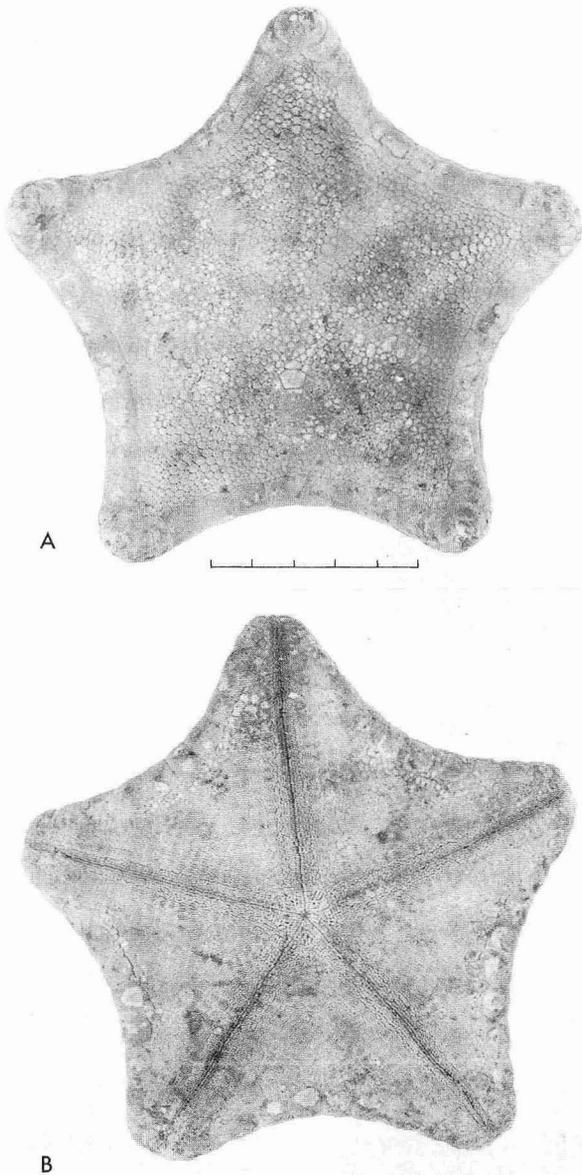


FIGURE 26.—*Peltaster planus*. A, aboral; B, oral. 5 cm. indicated.

rhombic, covered with granules. Adambulacrals numerous, crowded, with 3 to 4 marginal spines in row; outside of these are 9 to 12 thicker, obtuse spines in four irregular rows; all adambulacrals resemble the actinal granules, which are large, angular. No pedicellariae. $Rr=1.4:1$. Color pale yellowish brown.

Range:

Cape Cod to Cape Hatteras, 180 to 365 m. North Carolina specimens have come mainly from north of Cape Hatteras.

SPINULOSIDA

None of the species of the Order Spinulosida are common in North Carolina. Although the two "northern" species are very abundant north of the State, they are rarely taken in North Carolina waters. The "southern" species have been taken only in Onslow Bay.

***Solaster caribbaeus* Verrill, 1915**

Description:

Disc rather large, arms six to eight. Dorsal surface covered with numerous paxillae which are crowned with many long fine spinules. Papulae in rather regular rows from center out along arms. Inferomarginals conspicuous, forming distinct fringe around border; superomarginals not distinct from dorsals. Adambulacrals with inner furrow comb of three to four webbed spines and outer transverse comb of about four larger spines. Oral spines eight, with middle two largest and longest. Anus central, protected by spines of adjacent paxillae. Madreporite inconspicuous. Species known only from small, probably juvenile specimens. $Rr=2.6:1$. Color in life unknown, preserved, pale beige.

Range:

Known previously only from the West Indies, 30 to 230 m. A single specimen has been taken from a reef in Onslow Bay.

***Porania insignis* Verrill, 1885**

Description:

Convex disc, five short rays. Dorsal surface smooth, covered with thick, leathery skin. Papulae elongate, in irregular bands from near center of disc out along either side of rays; single or double row between superomarginals and inferomarginals. Lower marginals with one to four sharp, conical, skin-covered spines, forming fringe around body. Adambulacrals with transverse row of two to three short stout spines, webbed at base, outer one stoutest. Two short, skin-covered oral spines on each jaw, and two to three on each side of jaw. Actinal radial furrows conspicu-

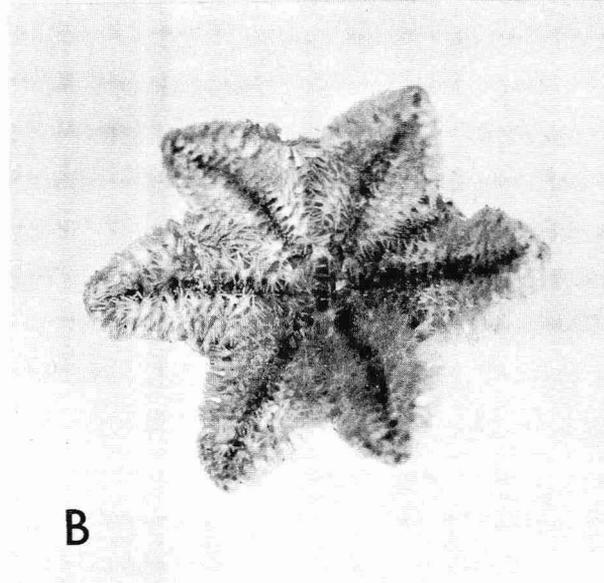
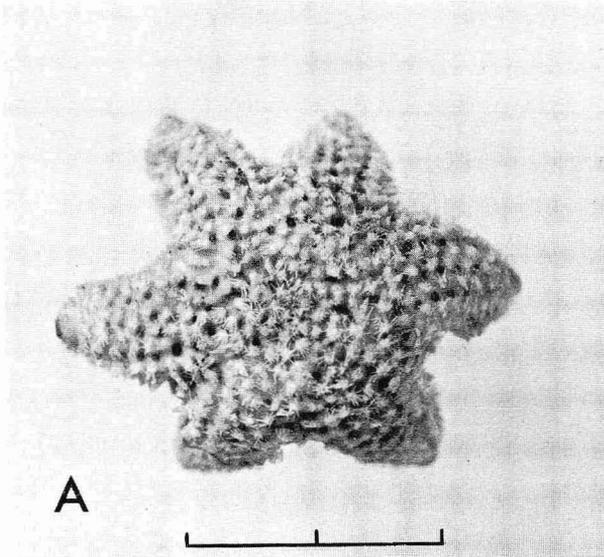


FIGURE 27.—*Solaster caribbaeus*. A, aboral; B, oral. 2 cm. indicated.

ous. $Rr=1.6:1$. Color red or reddish brown above, cream or white below.

Range:

Cape Cod to Cape Hatteras, 35 to 680 m. Seemingly limited in North Carolina to the area north of Cape Hatteras.

Thyrastrer serpentarius (Mueller and Troschel)

Synonymy:

Echinaster serpentarius Mueller and Troschel, 1842.

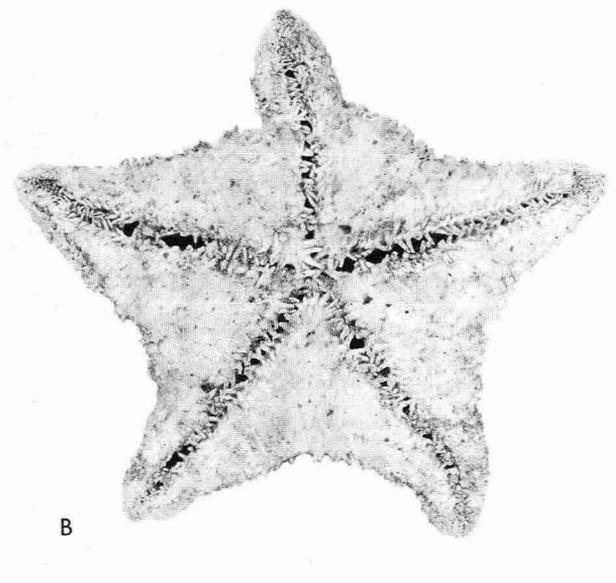
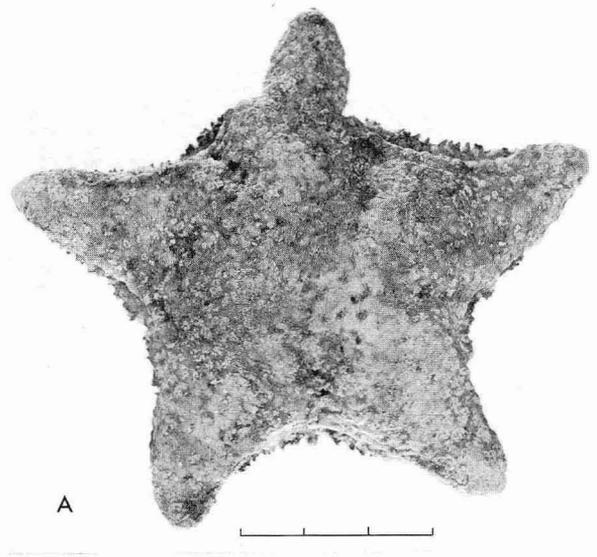


FIGURE 28.—*Porania insignis*. A, aboral; B, oral. 3 cm. indicated.

Thyrastrer serpentarius Ives, 1890.

Description:

Disc small, arms five, subcylindrical. Skeleton of quadrangular plates, overlapping at their corners, and arranged in very regular longitudinal series. Three to four small spines on distal edge of dorsal plates. Three to four spines on distal margin of adambulacral plates, with a small furrow spinelet. Tips of all spines thorny; plates minutely tuberculated. Papular areas rounded, regular, with

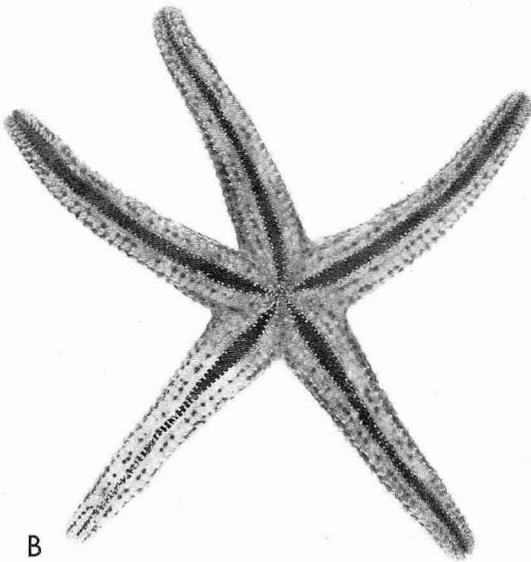
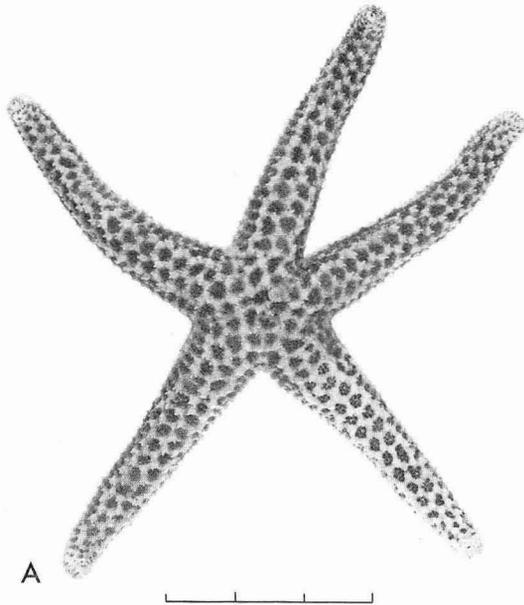


FIGURE 29.—*Thyrastrer serpentarius*. A, aboral; B, oral. 3 cm. indicated.

about 10 pores per area. Madreporite raised, channeled, warty. $Rr=4:1$. Color reddish brown.

Range:

North Carolina to Florida, Alabama, and Louisiana; Vera Cruz, Mexico, 9 to 75 m. In

North Carolina mainly on reefs in Onslow Bay.

***Henricia sanguinolenta* (Sars)**

Synonymy:

- Asterias sanguinolenta* Müller, 1777.
- Asterias pertusa* Müller, 1777.
- Asterias oculata* Pennant, 1777.
- Asterias spongiosa* Fabricius, 1780.
- Asterias seposita* Retzius, 1783.
- Linckia oculata*: Forbes, 1839.
- Henricia oculata*: Gray, 1840.
- Cribella oculata*: Forbes, 1841.
- Echinaster oculatus*: Mueller and Troschel, 1842.
- Echinaster sanguinolentus* Sars, 1844.
- Echinaster sarsii* Mueller and Troschel, 1842.
- Linckia pertusa*: Stimpson, 1853.
- Cribella sanguinolenta*: Lütken, 1857.
- Cribella oculata*: Fischer, 1869.
- Henricia sanguinolenta*: Grieg, 1896.

Description:

Disc small, rays five, slender, pointed, cylindrical. Disc and arms evenly covered with small spinules on network of fine, closely reticulate plates. Papular pores numerous. Superomarginals small, indistinct, like aboral plates; inferomarginals larger. Adambulacrals transversely oblong. One to two furrow spines; actinal face of adambulacrals with numerous fine spinules. No pedicellariae. $Rr=5-7:1$. Color commonly bright red, but may be orange, green, purple, or brown.

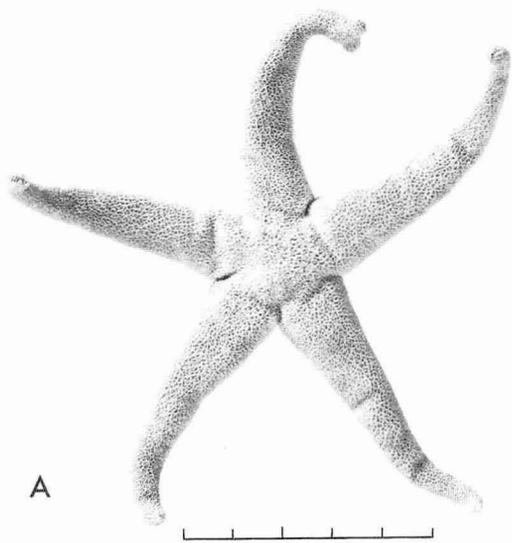
Range:

Circumboreal and south to about lat. 35° N., 55 to 2,400 m. Rare in North Carolina and limited to the cold waters north of Cape Hatteras.

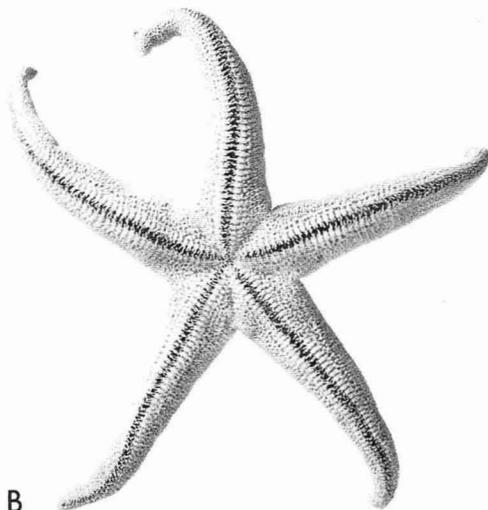
***Echinaster spinulosus* Verrill, 1869**

Description:

Disc small, rays five, long, slender, tapered. Fifteen to 20 rows of 40 or more small, conical, subacute spines on aboral plates, often 2 or 3 to a plate. The two rows of marginals larger and more rounded than abactinal plates, and with a well defined patch of glassy granules. Each also bears one small conical spine. Most of the aboral plates also have a patch of glassy granules. Papular pores numerous, but none below inferomarginals. Adambulacrals with two small furrow spines and a stouter, conical

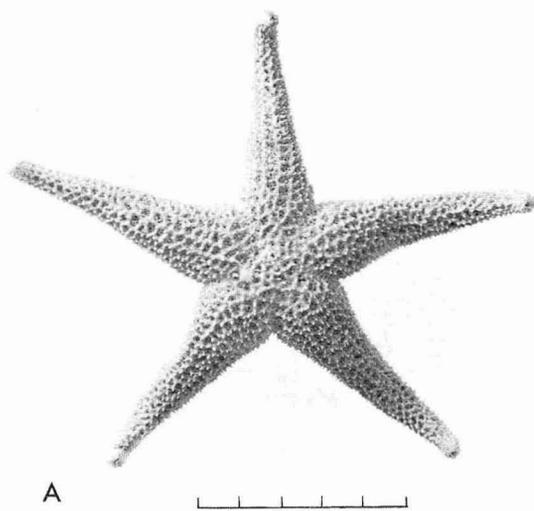


A

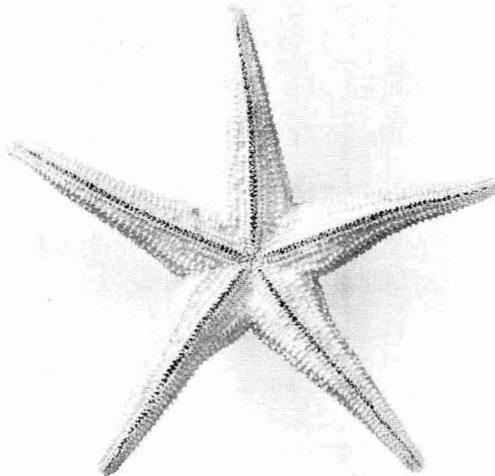


B

FIGURE 30.—*Henricia sanguinolenta*. A, aboral; B, oral.
5 cm. indicated.



A



B

FIGURE 31.—*Echinaster spinulosus*. A, aboral; B, oral.
3 cm. indicated.

spine on the outer margin. Madreporite prominent, flattish, wartlike. The whole body invested in moderately thick dermis. $Rr=4:1$. Color dark red, purple, or reddish brown.

Range:

North Carolina to west coast of Florida and Gulf of Mexico, shore to 60 m. Found on reefs in Onslow Bay. Seemingly reported in North Carolina for the first time by Pearse and Williams (1951) from a reef off New River Inlet.

***Echinaster sentus* (Say)**

Synonymy:

Asterias sentus Say, 1825.

Echinaster sentus: Lütken, 1871.

Description:

Disc small, rays five, of moderate length, rounded. Aboral spines in five irregular rows, median row most distinct. Larger aboral plates sometimes have two to three spines, but usually one. Two marginal rows of plates

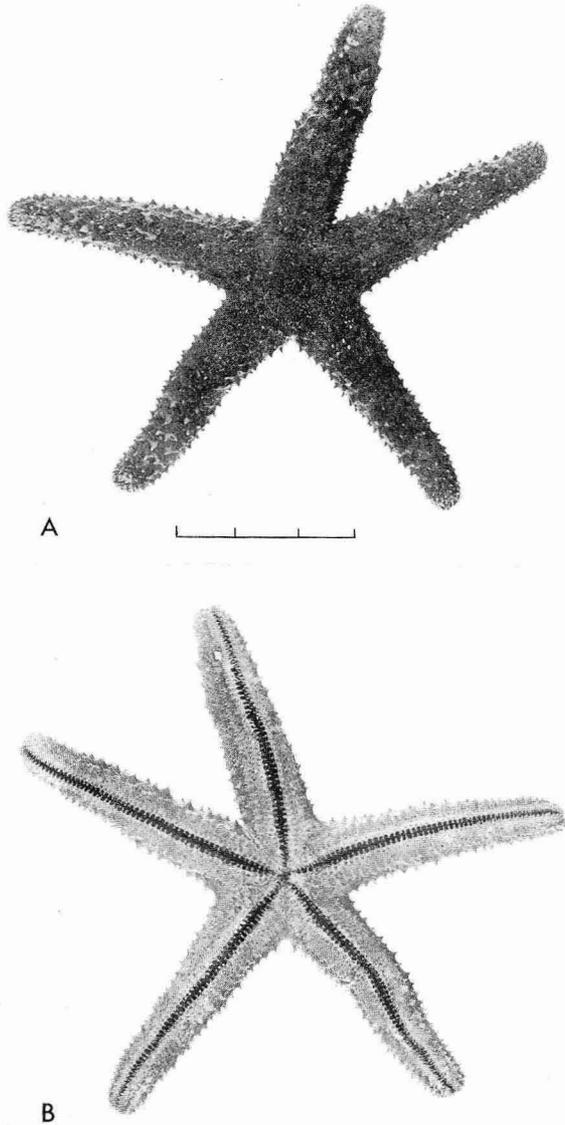


FIGURE 32.—*Echinaster sentus*. A, aboral; B, oral. 3 cm. indicated.

fairly regular, but do not differ from other plates in size or form. Superomarginals with one stout, conical spine, on mammiform base, on each plate. A single row of small oblong plates connects the inferomarginals with the adambulacrals. Adambulacral spines small, subacute, in oblique transverse series of three. Two webbed furrow spines, inner one much smaller. Papulae numerous, papular areas large, extending to adambulacrals. Madre-

porite raised, flat, covered with rough spinules. Rr=4:1. Color dark red or purple.

Range:

North Carolina to West Indies, shallow water. Found on reefs in Onslow Bay, often in association with *E. spinulosus*.

Echinaster brasiliensis Mueller and Troschel

Synonymy:

(?) *Othilia brasiliensis* A. Agassiz, 1869.
Echinaster brasiliensis Mueller and Troschel, 1842.

Description:

Disc small, rays five, slender, terete. Dorsal spines small, sturdy, acute-conical, in 9 to 11 rows. Marginals not distinct from aborals. Papular areas of moderate size, numerous on aboral surface, less numerous on oral surface. Three adambulacral spines: furrow spine small, curved, two outer spines sturdy, divergent, subequal. Madreporite small, warty, covered with rough spinules. Rr = 5:1. Color rust red above, paler below.

Range:

North Carolina to Florida and Brazil, shallow water. Our only locality record for this species is at the edge of the shelf northeast of Cape Hatteras.

FORCIPULATIDA

All North Carolina species in the Order Forcipulatida may be found north of Cape Hatteras, and a few also occur south of the Cape. The well-known and widespread shallow water *Asterias forbesii* is the most abundant. North of Cape Hatteras, the tropical species *Coscinasterias tenuispina* and *Stephanasterias gracilis* occur only near the outer edge of the shelf.

Asterias forbesii (Desor)

Synonymy:

Asteracanthion forbesii Desor, 1848.
Asterias arenicola Stimpson, 1862.
Asterias forbesii: Verrill, 1866.

Description:

Disc moderate, often domed. Rays five, stout, cylindrical, blunt. Upper surface a firm mosaic of strong interlocking plates, each bearing a single large, blunt, rough-tipped spine encircled by a few smaller spines. Small pedicellariae encircle each spine, and larger pedicellariae are scattered over the surface. Ad-

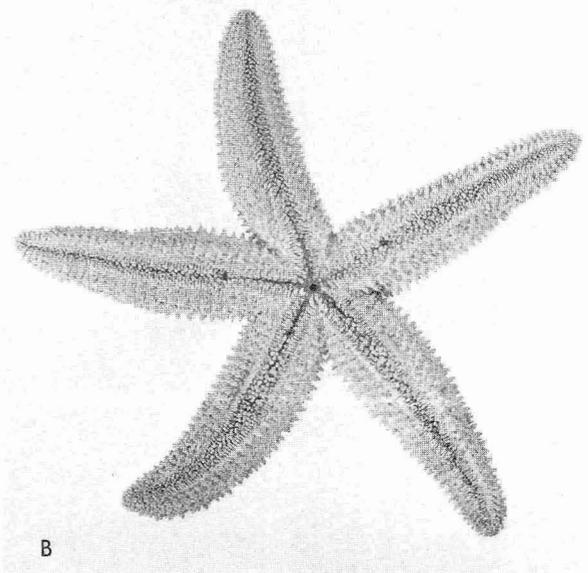
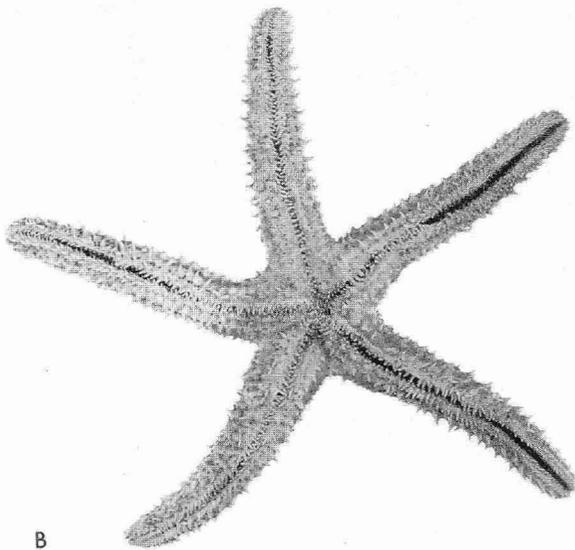
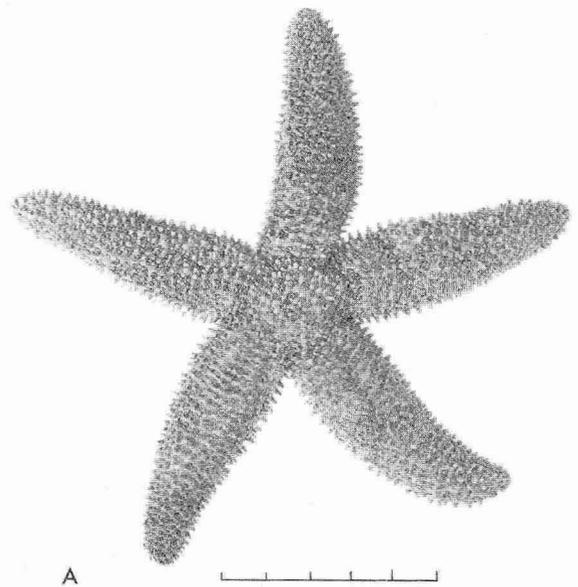
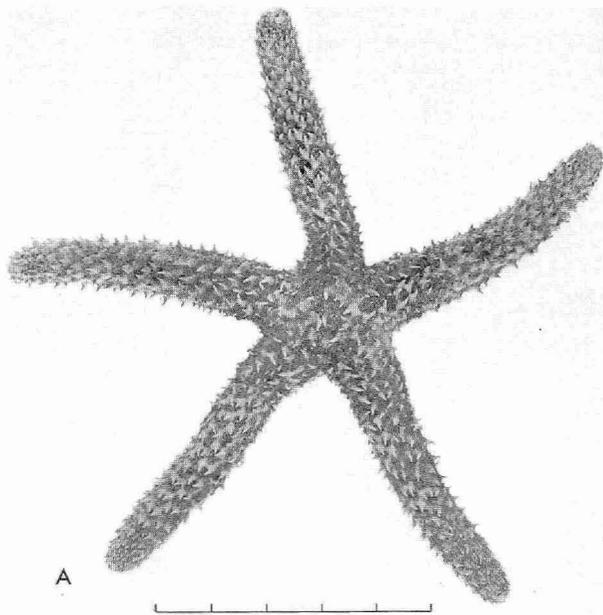


FIGURE 33.—*Echinaster brasiliensis*. A, aboral; B, oral. 5 cm. indicated.

FIGURE 34.—*Asterias forbesii*. A, aboral; B, oral. 5 cm. indicated.

ambulacrals with one or two flattened, truncate, long, slender spines. Madreporite small, smooth, channeled, without warts, tubercles, or spinules. $Rr=3:1$. Color reddish brown, madreporite usually bright orange or red.

Range:

Maine to Gulf of Mexico, to 92 m. This shallow

water species is the best known sea-star along the Atlantic coast and is the one most frequently used in biology classes. Large individuals, common in winter but less so in summer, inhabit hard substrates, such as jetties, pilings, shell bottoms, and wrecks, in shallow water along the North Carolina coast and

in the estuaries. In summer, the trawls of commercial fishermen take many small individuals.

Asterias vulgaris Verrill

Synonymy:

Asterias vulgaris Packard, 1863 (nomen nudum).

Asterias stimpsoni Verrill, 1866.

Asterias vulgaris Verrill, 1866.

Asterias pallida: Perrier, 1875.

Asterias fabricii Perrier, 1875.

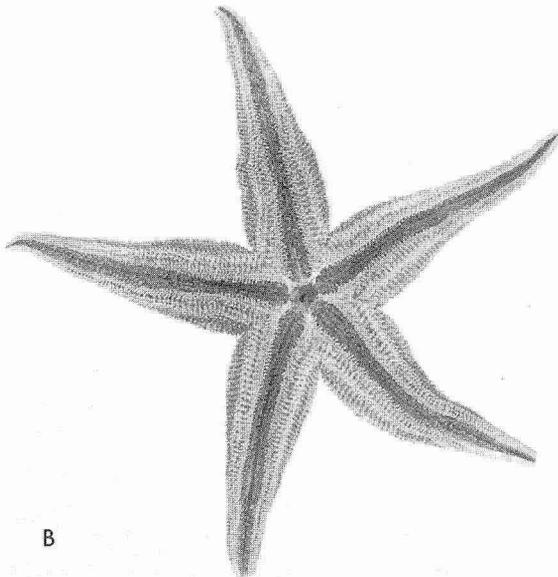
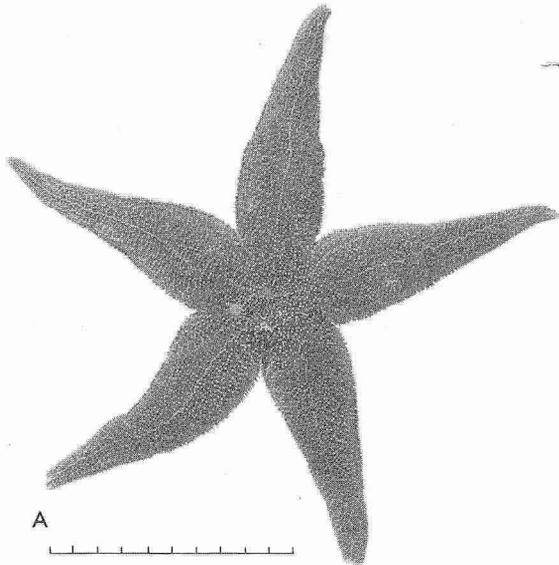


FIGURE 35.—*Asterias vulgaris*. A, aboral; B, oral. 10 cm. indicated.

Description:

Disc of moderate size, arms five, more flattened and pointed than in *A. forbesii*. Aboral surface a network of narrow barlike plates with large meshes, making a fairly weak skeleton. Clearly perceptible row of median plates. All plates with one or more blunt spines with rough tips, encircled by a wreath of blunt pedicellariae. Large acute pedicellariae along sides of arms, rising directly from dermis. Inferomarginals with conspicuous series of long, truncate spines. Adambulacrals with one or two long, flattened spines. Rr=3:1. Color reddish brown, madreporite usually yellow.

Range:

Labrador to Cape Hatteras, shore to 650 m. Uncommon in North Carolina, where it is limited to the cold waters north of Cape Hatteras.

Asterias tanneri Verrill, 1880

Description:

Disc small, arms five, slender, terete. Aboral spines blunt, rather large and conspicuous, encircled with wreath of small pedicellariae about half way up the spine. Adambulacrals long, slender. Jaw plates long, narrow, with two pairs of large, conspicuous spines. Madreporite very small. Rr=5.5:1. Color pale yellowish.

Range:

New Jersey to Cape Hatteras, 35 to 350 m. In North Carolina it has been taken at several stations north of Cape Hatteras.

Coronaster briareus (Verrill)

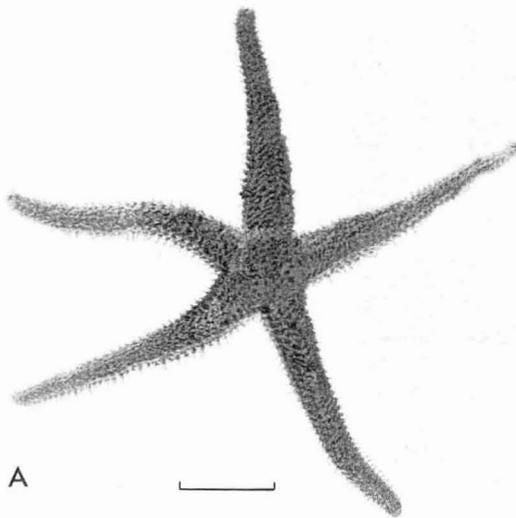
Synonymy:

Asterias briareus Verrill, 1882.

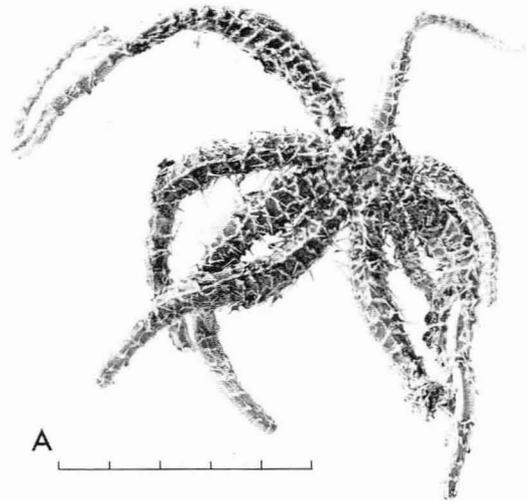
"near *Asterias volsellata*" Nutting, 1895.

Description:

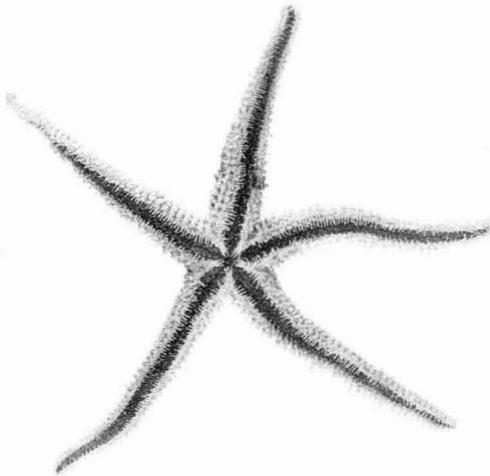
Disc small, rays 10 to 12 slender, elongate. Aboral skeleton openly reticulate, with marked median carina. Marginal plates also form ridges. Aboral and marginal spines long, slender, acute, well separated. Large rectangular papular areas, with numerous papulae in clusters. Spines bear dense wreath of small pedicellariae. Large solitary feliped pedicellariae scattered on dermis above and below. Adambulacrals with two long, slender spines.



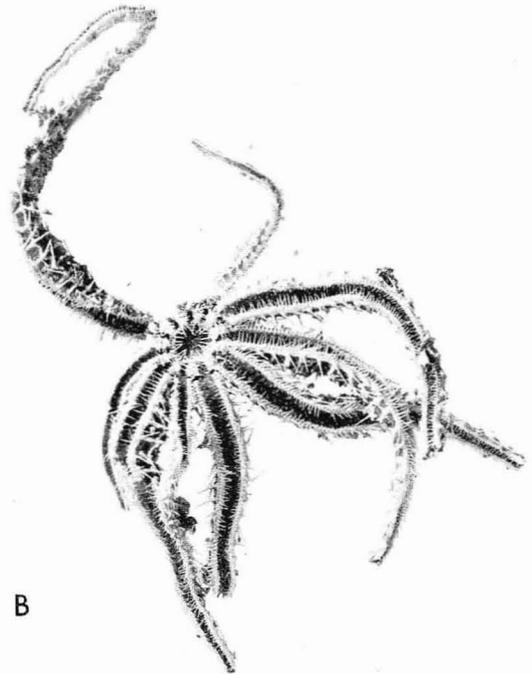
A



A



B



B

FIGURE 36.—*Asterias tanneri*. A, aboral; B, oral. 1 cm. indicated.

Rr=9.5:1. Color in life unknown; preserved, pale beige.

Range:

Virginia to Key West, Fla., 35 to 75 m. So far this species has been found at only one station—North of Cape Hatteras in about 40 m.

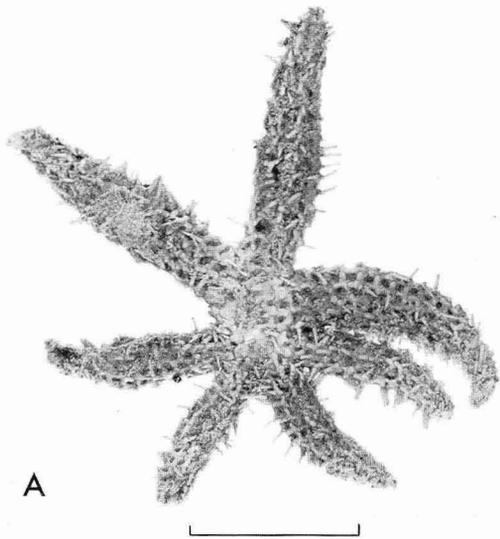
FIGURE 37.—*Coronaster briareus*. A, aboral; B, oral. 5 cm. indicated.

Coscinasterias tenuispina (Lamarck)

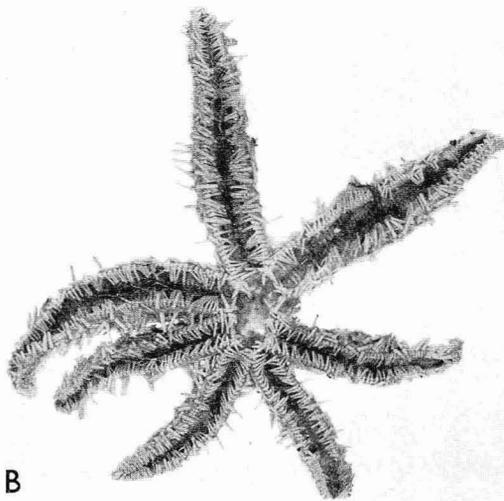
Synonymy:

Asterias tenuispina Lamarck, 1816.

Asteracanthion tenuispinus: Mueller and Tro-schel, 1842.



A



B

FIGURE 38.—*Coscinasterias tenuispina*. A, aboral; B, oral.
1 cm. indicated.

Asterias (*Stolasterias*) *tenuispina*: Sladen, 1889.

Coscinasterias tenuispina: Verrill, 1914.

Asterias atlantica (pars) Verrill, 1868.

Description:

Disc small, rays four to nine (most commonly seven), long, slender, angular. Aboral and marginal spines elongate and slender. Aboral

plates form definite carinal row and one main dorso-lateral row on each side; each plate with one spine. Superomarginals and inferomarginals with one or two spines, longer than aboral spines. Adambulacrals with one long slender spine. Usually two or more madreporites present. $Rr=10:1$. Color yellowish brown, with darker markings.

Range:

Mediterranean, Madiera, Canary Islands, Cape Verde Islands, Brazil, Cuba, Bermuda, West Indies. In North Carolina, 20 to 165 m. South of Cape Hatteras it has been found on reefs off New River Inlet and Cape Lookout; north of Cape Hatteras it occurs along the edge of the shelf in 145 to 165 m.

Stephanasterias gracilis (Perrier)

Synonymy:

Asterias gracilis Perrier, 1881.

Stephanasterias gracilis: Verrill, 1879.

Description:

Disc small, rays about six, often unequal, slender. Aboral surface closely covered with numerous minute slender spines, several to a plate. Marginal spines larger, flattened, and expanded at tip, which is blunt, thorny, and more or less hyaline. Adambulacrals with two short, slender, slightly clavate spines. $Rr=4.5:1$. Color in life unknown; preserved, white.

Range:

Lesser Antilles, Gulf of Mexico, Cuba, and Florida, 145 to 370 m. Although a southern species, it has been taken in North Carolina only north of Cape Hatteras—at several stations along the edge of the outer shelf.

Leptasterias tenera (Stimpson)

Synonymy:

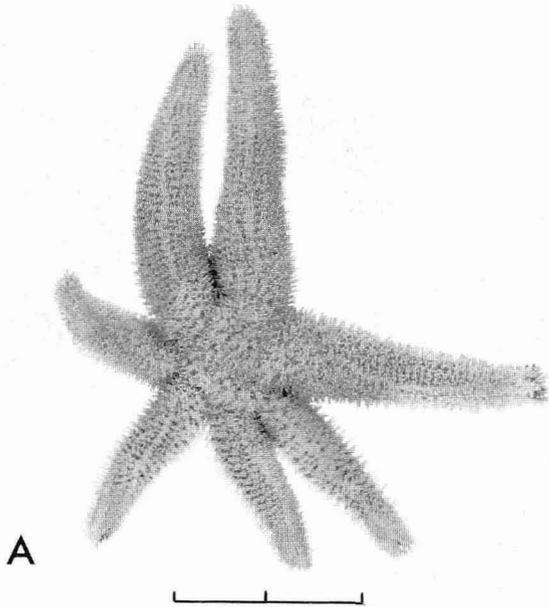
Asterias tenera Stimpson, 1862.

Asterias compta Stimpson, 1862.

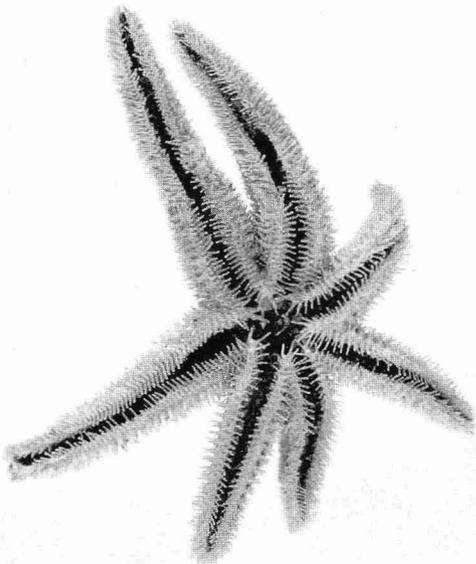
Leptasterias compta: Verrill, 1866.

Description:

Disc moderate, rays five, slender, cylindrical, tapering to small blunt tip. Conspicuous slender spines rising from open network of aboral plates, no clear median row on arms. Wreath of pedicellariae around aboral spines. Adambulacrals long, blunt-tipped. Madreporite inconspicuous. $Rr = 5:1$. Color



A



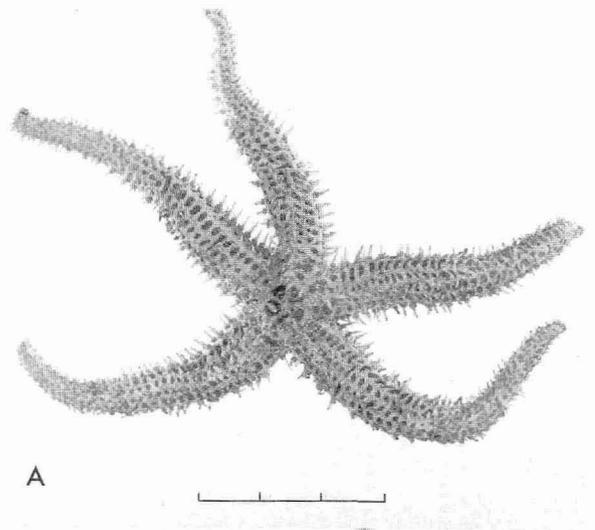
B

FIGURE 39.—*Stephanasterias gracilis*. A, aboral; B, oral. 1 cm. indicated.

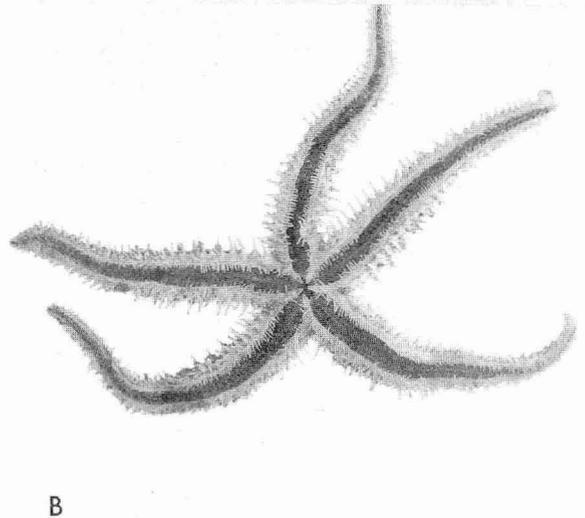
pale purple or pink, red eyespot at tip of arm.

Range:

Nova Scotia to North Carolina, 18 to 150 m. A cold-water species limited, in North Carolina, to the area north of Cape Hatteras in 30 to 145 m.



A



B

FIGURE 40.—*Leptasterias tenera*. A, aboral; B, oral. 3 cm. indicated.

ACKNOWLEDGMENTS

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